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Long-Term Effects of Land Application of Domestic Wastewater; Mesa, Arizona Irrigation Site

Ralph Stone and Co., Inc.
Los Angeles, CA

Prepared for

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Mesa, Arizona: Irrigation Site

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April 1980

LONG-TERM EFFECTS OF LAND APPLICATION OF DOMESTIC WASTEWATER MESA, ARIZONA: IRRIGATION SITE

by

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FOREWORD

The Environmental Protection Agency was established to coordinate the administration of major Federal programs designed to protect the quality of our environment.

An important part of the agency's effort involves the search for information about environmental problems, management techniques, and new technologies through which optimum use of the nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized.

EPA's Office of Research and Development conducts this search through a nationwide network of research facilities. As one of these facilities, the Robert S. Kerr Environmental Research Laboratory is responsible for the management of programs including the development and demonstration of soil and other natural systems for the treatment and management of municipal wastewaters.

Although land application of municipal wastewaters has been practiced for years, there has been a growing and widespread interest in this practice in recent years. The use of land application received major impetus with the passage of the 1972 amendments to the Federal Water Pollution Control Act. The 1977 amendments to the Act gave further encouragement to the use of land application and provided certain incentives for the funding of these systems through the construction grants program. With the widespread implementation of land application systems, there is an urgent need for answers to several major questions. One of these questions regards the long-term effects of land application on the soil, crops, groundwater, and other environmental components. This report is one in a series of ten which documents the effects of long-term wastewater application at selected irrigation and rapid infiltration study sites. These case studies should provide new insight into the long-term effects of land application of municipal wastewaters.

This report contributes to the knowledge which is essential for the EPA to meet the requirements of environmental laws and enforce pollution control standards which are reasonable, cost effective, and provide adequate protection for the American public.

William C. Galegar
Director
Robert S. Kerr Environmental Research Laboratory

ABSTRACT

This report presents the results of an assessment of the long-term impacts on crops, soils, and groundwater resulting from irrigation with secondary-treated municipal effluent. The concentrations of pathogens, nutrients, heavy metals and salts in soils, groundwater, and crops irrigated with secondary-treated wastewater were compared to the concentrations in soils, groundwater, and crops irrigated with conventional water supplies. Test and control sites at Mesa, Arizona, were selected as case studies for comparisons. Both sites produced ensilage or other crops not used for human consumption. The control site was furrow irrigated and the test site was flood and furrow irrigated. The test site had been irrigated with effluent for over ten years. The control site had never received wastewater but had been irrigated for at least ten years with conventional water. Lysimeters were placed at various depths in the soil of both sites to test for the constituents in the leachate. Sampling wells were drilled at the test and control sites to determine the upper groundwater quality affected by the leachate.

This report was submitted in fulfillment of Contract No. 68-03-2362 by Ralph Stone and Company, Inc., under the sponsorship of the United States Environmental Protection Agency. This report covers the period from January 2, 1976 to February 28, 1978, and work was completed as of May 3, 1978.

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LIST OF SPECIAL ABBREVIATIONS[a]

ABBREVIATIONS

AE	--	acid extractible
C	--	composited sample (i.e., the sample was composited with another sample)
CEC	--	cation exchange capacity
EX	--	exchangeable
Fa	--	fall
FC	--	fecal coliform
NA	--	not available
NES	--	not enough sample
Org	--	organic
Sp	--	spring
Su	--	summer
T	—	total digestible
TC	--	total coliform
TDS	--	total dissolved solids
TOC	--	total organic carbon
W	--	winter
WE	--	water extractible

---

[a] Conventional biological and chemical symbols and abbreviations are not included in the above listing.

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SECTION 1

INTRODUCTION

The widespread application of treated wastewater for irrigation is limited primarily by certain economic, technical and public health uncertainties about the impacts of such use. In addition to costs, there is concern that the quality of our foodstuffs, land resources, and groundwater resources may be partially impaired due to residual contaminants present in the treated effluent. For instance, high total salt concentration (salinity) of irrigation water can greatly reduce the total crop yield. Concentrated dissolved solids can severely deter plant growth. The salt content of the soil moisture strongly affects the osmotic relationships within plants since high salinity interferes with the plants' ability to take up water. Furthermore, saline irrigation water may create an unfavorable nutrient balance in the soil. Undesirable concentrations of toxic heavy metals or salts in treated effluent may originate from the discharge of noxious chemicals by manufacturing plants, commercial or even domestic sources having, for example, photographic dark rooms or zeolite water softeners.

Salinity may also adversely affect the structure of the soil by changing the chemical and physical properties of clays and other minerals. For instance, when calcium is the predominant cation, the soil usually has a granular structure which is easily worked and readily permeable. As the calcium is replaced by sodium, however, the clay becomes dispersed and the soil becomes less workable and more impermeable.

Trace heavy metals and other toxic constituents in the irrigation water may be dangerous for two reasons. Many trace metals are phytotoxic. Aluminum, boron, copper, manganese, selenium, and silver are some of the more notable examples. Phytotoxins may kill a plant outright, but more often they inhibit and weaken its growth, reduce yield, or produce a food product of inferior quality. Another potential problem lies in biomagnification- the tendency for many plants to absorb and concentrate some toxic substances. This tendency is pronounced in the case of the absorption of mercury by aquatic algae and fish in the food chain, but similar problems may occur in terrestrial plants, albeit to a lesser extent. Some of the toxic substances which are subject to biomagnification are cadmium, molybdenum, selenium, and fluoride. In food crops, this could present a hazard to human health. The significance of long-term application of heavy metals to agricultural soils from wastewater irrigation will depend on whether these metals are ultimately absorbed by plants, they assume inert chemical forms in the soil that cannot be absorbed by plants, or they are leached into the groundwater.

Pathogens can also be a problem when irrigating with sewage effluent. This is of particular concern when the crop is to be consumed raw by humans. Pathogenic protozoa, bacteria, viruses and other organisms can enter plant tissues in a variety of ways and may even be found in the edible portion of the plant. One solution to this problem is to irrigate only grasses or pasture land with reclaimed water; however, there is still concern about possible bacterial or other infection of grazing livestock. Some pathogens present in raw sewage may also represent a hazard to the plants. Certain fungi,bacteria,protozoa, and nematodes can attack vegetation,damaging the growing plant and severely affecting the yield.

Dissolved salts, heavy metals, and pathogens also pose a potential danger to the usable groundwater supplies. Usually, the nature of the soil is such that insoluble solids, some ions, heavy metals, and pathogens are effectively removed by adsorption, precipitation, or exchange within the first few feet of fine-grained soil. However, a bypass of raw sewage, such as through an uncapped well or bedrock fissure directly into potable groundwater aquifers, may cause an epidemic or other contaminative outbreak. Nevertheless, land disposal in general, has been found to be a superior biological filter, greatly reducing health hazards and other adverse environmental impacts when contrasted with water disposal.

Before irrigation with sewage effluent can be significantly expanded, a detailed assessment of its long-term effects is required. The purpose of this study was to evaluate the long-term environmental and cost impacts resulting from irrigating farmland with secondary treated municipal effluent. The major areas of concern were: impact of the wastewater on groundwater, soils and crop quality; changes in the crop yield and uptake of minerals; costs of crop production using wastewater; and the environmental health hazards. Specifically, the objectives were to:

- Sample soils (at the beginning and the end of the monitoring program), harvested crops, and water (irrigation water, leachate, and upper groundwater).
- Contrast the effluent-treated test site biological (including pathogens), physical and chemical characteristics of the soils, crops, irrigation water, percolating water and groundwater with similar data obtained at the control site.
- Contrast the agricultural costs and crop yields.
- Evaluate other environmental and health effects.

The first step in implementing the study was to select a separate effluent irrigation site and a paired normal irrigation site.This was done by reviewing a computerized list of existing effluent irrigation sites supplied by the U. S. Environmental Protection Agency, as well as by reviewing current literature. A group of 5 candidate sites in Arizona were selected for intensive technical evaluation based on the preselection criteria. Of these, two locations were chosen for visitation and final review. Mesa, Arizona, classified as having an arid climate, was ultimately selected for the assessment of the long-term environmental impact of irrigating with sewage effluent. Separate test and control sites were obtained.

Site specific but uniform monitoring programs for both the test and control sites at Mesa were developed. Soil samples, collected from several depths at the beginning and at the end of the monitoring program, were examined for biological organisms and physical properties, and analyzed for chemical constituents (including nutrients, heavy metals and salts).

The tissues of harvested crops were tested for pathogens and chemical constituents. Chemical and biological analyses were made twice each month on the irrigation waters (treated effluent from the test site and municipal water supply from the control site), percolating water, and upper groundwater. The data collection, laboratory analyses, and office studies were conducted over a 24-month period, including 18 months of field sampling from August 1976 to January 1978.

SECTION 2

CONCLUSIONS

The long-term effects from crop irrigation of municipal secondary treated wastewater were evaluated by comparing a test site irrigated for over 10 years with secondary treated effluent, with a similar control site irrigated with normal potable water. General conclusions on land disposal by crop irrigation include those related to overall site and effluent impacts and requirements.

Due to a combination of variable crop irrigation schedules and the total irrigation volume being less than the effluent volume, facilities for effluent storage and bypass into a stream bed were needed at Mesa. Where sufficient cropland is available to utilize all of the effluent from a wastewater plant for crop irrigation, storage facilities would still be needed due to the variable crop irrigation schedules.

Irrigation water was applied by furrow irrigation at the test and control sites when the crops had grown above ground. Avoidance of spray irrigation reduced the potential public exposure to the wind-blown effluent. No flies or sewage odors were detected on the effluent irrigated test site. After over 16 years of continuous land disposal of effluent at Mesa, no adverse health effects were reported on farm workers, consumers, or waste-treatment plant personnel. Available information on the incidence of illness of farm and treatment plant workers indicated no difference from other local farm or industrial workers. A well oxidized, clear, odor-free disinfected effluent is desirable to avoid potential dangers and nuisances that may be associated with effluent land disposal.

Farmers and their advisors were neither knowledgeable about nor saw great benefits in using reclaimed wastewater effluent for crop irrigation. Education and information programs for farmers on the availability and cost benefits of using effluent for crop irrigation would enable farmers to more realistically assess effluent irrigation for their crops.

Although use of treated wastewater for land irrigation requires a separate set of water pumping and distribution lines, the irrigation costs were lower when compared with conventional water supplies because of the lower cost of effluent.

The areas of concern in using treated effluent for irrigation water included: hazards to farm workers' health, contamination of the soils, crops, or the groundwater underlying the effluent irrigated site, changes in the crop yield, uptake of minerals and nutrients, costs, and nuisances. Specific conclusions concerning these latter impacts are presented below:

BIOLOGICAL AND CHEMICAL ANALYSIS OF WATER AND SOILS

1. The wastewater effluent applied to the test site had significantly higher total dissolved solids (about 27 percent) than the irrigation water applied to the control site; in particular, chlorides (40 percent) and sodium (43 percent). The effluent applied to to test site was 600 percent greater in total nitrogen, 180 percent greater in potassium, and 1,740 percent greater in phosphates than that applied to the control site. Boron, fluoride and total organic carbon were also significantly greater by 130, 182, and 200 percent, respectively, in the effluent applied to the test site. The heavy metals, total and fecal coliform were not significantly different between the test and control irrigation waters.

2. Highly reliable statistical analysis of the leachate was not possible because the number of samples was limited. The analytical data, however, indicate that no constituent in the test site leachate was found to be significantly different from the control site leachate at the 50-cm subsurface depths, and total coliform, magnesium and nickel were significantly lower for the 100-cm test site leachate.

3. The percolating water increased in total dissolved solids including chlorides and sodium, by as much as 50 percent from zero surface soil depth to 50-cm depth. At the test site, the total dissolved solids increased at the 100-cm depth whereas at the control site the total dissolved solids in the leachate decreased almost to the irrigation water level at the 100-cm depth. Nitrates at both sites increased with depth: by 3,200 percent in the test site leachate, and 580 percent in the control site leachate. The waste treatment process was effective in reducing the coliform count in the effluent. The total and fecal coliform counts decreased with depth by more than 99.5 percent at the 100-cm depth in both the test and control site leachate. The metals in the leachate samples did not significantly change with increased subsurface depths.

4. Total dissolved solids increased in the leachate entering the upper groundwater at both the test and control sites. Chlorides, which increased by 35 percent, sulfates by 20 percent, and sodium by 60 percent, were significantly greater in concentration in the downstream than the upstream control well. There were no significant differences observed in the other analyzed constituents between the upstream and the downstream control wells.

5. The most significant difference noted between the test site upstream test wells and the downstream test well was an increase of about 55 percent or more in total dissolved solids, chlorides, sodium, calcium, and magnesium content.

6. The organic content in the effluent as indicated by the total organic carbon and total and fecal coliform were effectively attenuated by percolation through the soil. Nitrates and boron in effluent percolated through the soil with little change and entered

into the groundwater.

7. In general, the test and control soils did not differ significantly in their biological and chemical characteristics. There were no significant changes in the biological characteristics between initial and final samplings. There was however, a decrease in concentration over time for approximately 50 percent of the analyzed chemical constituents.

GROUNDWATER QUALITY COMPARISON

The groundwater samples' analytical results for the study period were compared with the U. S. Environmental Protection Agency 1975 interim primary drinking water regulations and the water quality criteria for municipal water supplies. The percent of analyses which exceeded these standards were calculated for both the test site groundwater and the control site groundwater samples. The percent of time that the test site groundwater samples exceeded the aforementioned water standards was compared with the results found for the control site groundwater, as follows:

1. The groundwater samples at the test site exceeded the aforementioned water quality standards more often than the control site groundwater for total coliform (30 ± 7 versus 18 + 4 percent of the time, respectively), fluorides (8 ± 8 versus 0 percent), and arsenic (8 ± 12 versus 0 percent).

2. The test site groundwater exceeded the aforementioned water quality standards less often than the control site groundwater for chloride (47 ± 38 versus 98 ± 5 percent, respectively), and chromium (18 ± 2 versus 25 ± 9 percent).

3. The groundwater at the test and control sites exceeded the aforementioned water quality standards by similar percentages of time for fecal coliform (1 ± 3 versus 4 ± 5 percent, respectively), total dissolved solids (98 + 4 versus 100 percent), nitrates 22 +24 versus 24 + 26 percent), cadmium (43 ± 6 versus 42 ± 7 percent), and lead 69 ± 14 versus 65 ± 22 percent).

4. The following constituents did not exceed water quality standards in any of the well depths at either site: boron, sulfate, barium, copper, nickel, zinc, and selenium.

5. No significant trends were identified in any constituent between the two upstream, and one downstream test well and the two on-site control wells, nor between the two depths in any well.

CROP TISSUE ANALYSES

1. Test site corn leaves were lower than the expected ranges in boron, phosphorus, and magnesium.

2. Barley leaves at the test site were above the expected range for cadmium (2 versus 0 to 1 mg/kg) and lead (14 versus 0 to 10 mg/kg).

3. Cotton leaves and petioles grown on the control site exceeded expected ranges in mg/kg for cadmium (4.7 versus 0 to 3), chromium (1.7 versus 0 to 1), molybdenum (33 versus 0 to 10), nickel (9.3 versus 0 +2), and lead (100 versus 0 to 10).

SOIL NUTRIENTS

1. The test site soils evidenced a net depletion of nitrogen (904 kg/ha/yr) over a 13-year period. The control site soils were also depleted in nitrogen (53 kg/ha/yr), phosphorus (37 kg/ha/yr), and potassium (42 kg/ha/yr). Potassium (216 kg/ha/yr) and phosphorus (245 kg/ha/yr) accumulated in the test site soils.

CROP YIELDS

1. Crop yields for barley, sorghum, and wheat were similar over a 13-year period on the test and control sites. Since no commercial fertilizer was used on the test site, the nutrients in the effluent were sufficient to provide a normal crop yield.

CROP ECONOMIC ANALYSIS

1. The value of the nutrients (nitrogen, phosphorus, and potassium) provided by the effluent at the test site over a 13-year period was $4,460/ha or $343/ha/yr.

2. The total cost of crops on the effluent test site was less than the crops costs on the control site due to the use of effluent at no cost in place of purchasing potable water and fertilizer.

SECTION 3

RECOMMENDATIONS

1. Special studies on viruses present in effluent applied to and present in edible crops should be conducted. The studies would provide a meaningful data comparison for existing effluent and conventional water irrigation crop sites. Analyses should be conducted for selected viruses such as polio and influenza in the treated wastewater, soils, crops, leachate and groundwater.

2. Toxic elements found in the wastewater may enter crops. Standard bio-assay tests are recommended to assess the toxicity of the effluent, crops, soils, leachates, and groundwater at land disposal sites. Bio-assay methods should include bacterial tests, fish exposure, or other techniques. Biochemical oxygen demand or bacterial respiration tests should also be used as an indicator.

3. Plant and animal disease studies are desirable to assess the potential effects of effluent. The work should include field and controlled laboratory scale tests to define quantitative effluent parameters.

4. Epidemiological studies should be conducted on the health of the populations surrounding the effluent irrigation sites.

5. Public agency personnel, farmers, farm workers, and farm advisors associated with reclamation and conventional water supply sites should be surveyed for attitudes toward the effectiveness of wastewater land disposal irrigation.

6. Industrial wastewater pretreatment programs on plant effluent quality and land disposal should be investigated.

7. A demonstration and an educational program should be developed to acquaint farmers with the availability, usefulness and cost-effectiveness of effluent for crop irrigation.

8. Vertical type studies of the quality and marketability of effluent-irrigated crops starting with the farmer, processor and distributors through to the consumer should be performed.

9. Pilot tests and field demonstrations to optimize crop yields and define realistic effluent irrigation rates should be conducted.

10. The nutritional value of food or other crops grown with wastewater irrigation should be compared to food or other crops grown with conventional water.

11. Studies to assess the future viability of the land disposal alternative in areas where communities are rapidly growing should be performed. The survey should assess the availability of existing farm land for effluent irrigation, and the encroachment of various types of development on existing effluent irrigation programs.

SECTION 4

SITE SELECTION

PRELIMINARY SCREENING

The search for an appropriate test site began with a list provided by the United States Environmental Protection Agency indicating wastewater treatment plants in California, Nevada, and Arizona employing effluents for irrigation. This was supplemented by additional information obtained during a literature survey. From over 100 candidate sites, five Arizona sites were chosen for closer study. These 5 community sites, shown on Figure 1, were then evaluated by the criteria shown in Table 1. Based on these criteria, two Arizona sites were selected for final screening; they are also shown on Figure 1. Telephone calls and confirmatory letters were sent to the concerned authorities at the two selected sites to explain the project and to request their cooperation for field visits.

FINAL SELECTION

Two Arizona sites were ultimately selected as being potentially the best in fulfilling the general criteria. The summary data for Mesa and the alternate site are presented in Table 2. They were visited once again during February,1976, this time in the company of Dr. William R. Duffer, Project Officer. The review visits developed further information supplementing that previously gathered.

Initially, the Mesa site was not considered qualified because the reported annual rate of effluent application exceeded the criteria. However, there was no assurance that the alternate site would be cultivated after December,1976 when the farmer's lease expired. Accordingly, the search was renewed for additional Arizona sites; but of seven possible locations identified, none were considered completely satisfactory.

The Project Officer was then informed that the list of Arizona sites had been exhausted without locating a site fully meeting the selection criteria. Sites in California and Nevada falling into the same climatological Zone B (hot, semi-arid) were also analyzed. After considering all the factors, the Mesa site was selected in April 1976 and approved in May,1976. A detailed description of the project site is included as Appendix A,"Site Description." A map showing the Mesa study area is shown on Figure 2.

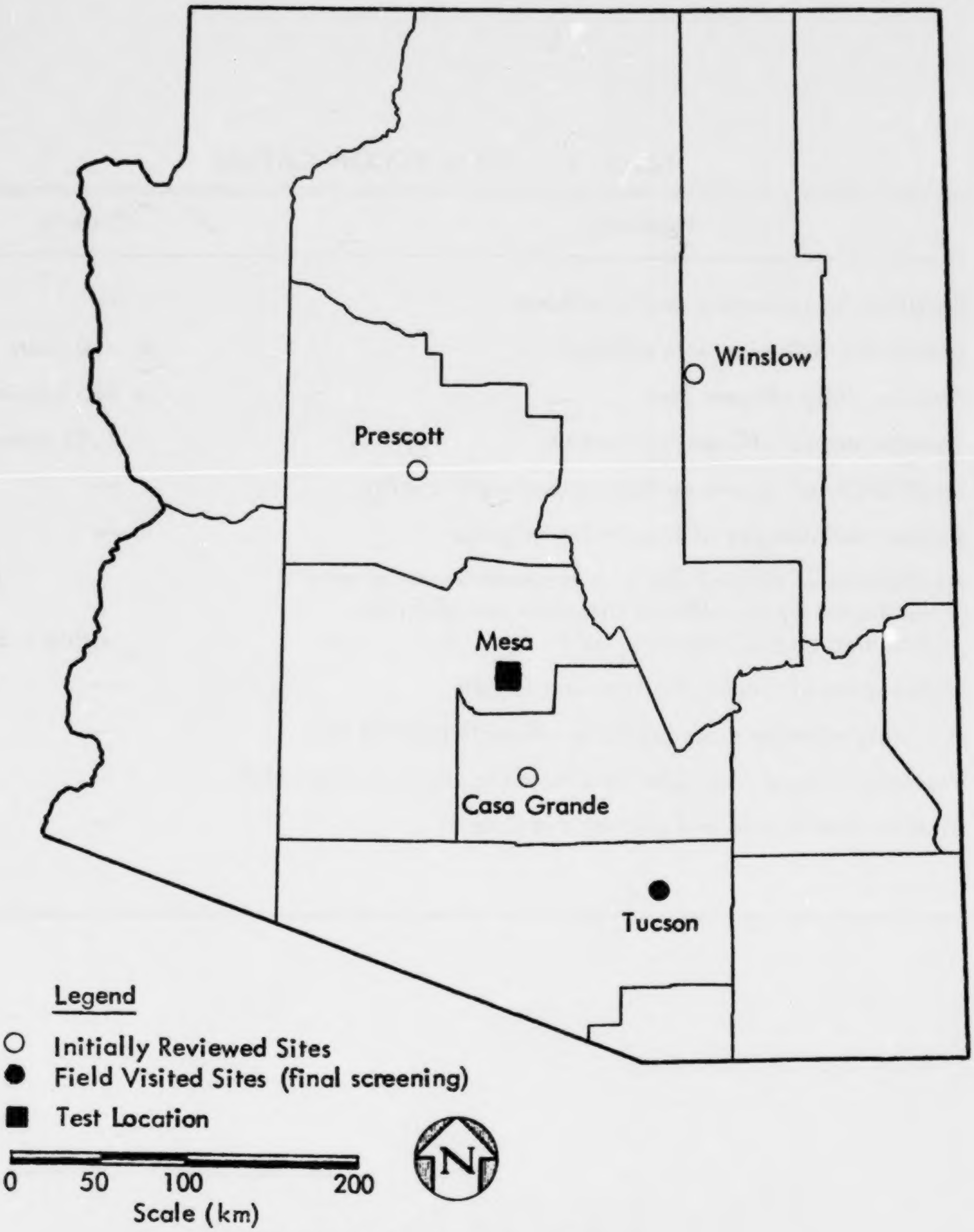

Winslow
Prescott
Mesa
Casa Grande
Tucson
Legend
○ Initially Reviewed Sites
● Field Visited Sites (final screening)
■ Test Location
0
50
100
200
Scale (km)
N

Figure 1. Site locations: Arizona.

TABLE 1. SITE SELECTION CRITERIA

Parameter	Criteria
Provision for secondary treated effluent	--
Continuous irrigation with effluent	≥ 10 years
Average daily effluent flow	≥ 365 kiloliters
Average annual effluent application	1.83 meters
Availability of records on local groundwater quality	--
Future continued use of the site for irrigation	--
Availability of the test site of a comparable control area unaffected by the effluent irrigation operation and receiving normal irrigation water	within 1.6 km
Cooperation of local authorities and farmers	--
A variety of major crops grown on effluent-irrigated land	--
Proximity of land receiving the effluent to the treatment plant	--
Sites located in arid and semi-arid regions	--

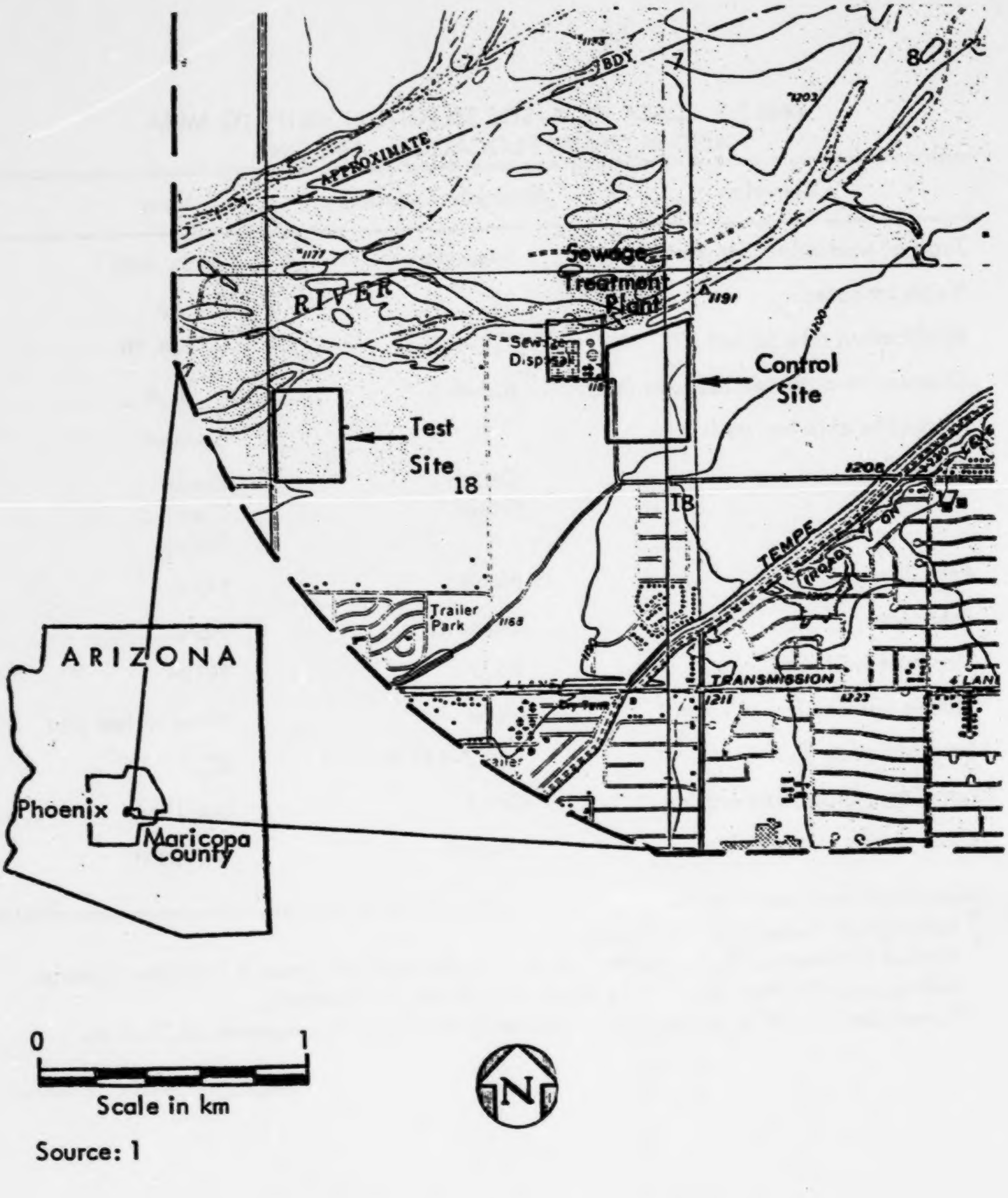
TABLE 2. DATA FROM SITE SELECTION VISITS TO MESA AND ALTERNATE LOCATION, ARIZONA

Criterion	Alternate Location	Mesa
Type of wastewater treatment	Secondary	Secondary
Years irrigated	22[a]	16
Application rate (m/yr)	1.2-1.5	6.1-9.1[b]
Distance to proposed test site (km)	6.5-8.1	0.4
Available existing wells	1	Several
Crops	Cotton Grain	Grain Corn Barley
Fertilizers	None	None
Pesticides	Unknown	None
Depth of wells (m)	76.2	19.8[c]
Sludge application to land	None	None to test site
Irrigated area (ha)	141.7-161.9	40.5
Local municipal cooperation	Good	Excellent
Local farmer cooperation	Limited	Excellent

[a] Interrupted 5 years ago for 2 years.

[b] Further information indicates that this is not the true rate since it includes recharge basins, and the true rate is only about 25 percent of the total.

[c] Subsequent to site selection visit, the drawdown level was measured at 33.5 m.


APPROXIMATE
BDY
7
8
1193
1203
1177
RIVER
Sewage Treatment Plant
1191
1200
Sewage Disposal
Control Site
Test Site
18
1208
18
TEMPE
Trailer Park
1168
TRANSMISSION
4 LANE
1211
1223
ARIZONA
Phoenix
Maricopa County
0
1
Scale in km
N

Source: 1

Figure 2. Study area – test and control farm sites.

SECTION 5

SAMPLING AND MONITORING PROGRAM

OBJECTIVES AND SCOPE

Following the site selection process outlined in Section 4, the general objectives described in Section 1 were implemented by developing a tentative sampling and analytical program. After submission to the Project Officer in June, 1976, the program was revised in September, 1976 to render it more site specific. The final field sampling and laboratory test program used for Mesa is presented in Table 3. Sampling procedures and analytical methods used are referenced in Appendix B.

TEST AND CONTROL SITE MONITORING

The comparison of critical parameters between an effluent-irrigated test site and a conventionally-irrigated control site is basic to the assessment of long-term effluent application effects. Monitoring and sampling activities on test and control sites at each location were identical and closely coordinated by timing to minimize external factors. Coordination of monitoring and sampling involved the following practices:

- o Using uniform field sampling methods and equipment.
- o Sampling test and control sites on the same day.
- o Using identical sample storage, handling, and analytical procedures.
- o Using the same personnel for sampling/analysis at both sites.

Where individual farm procedures or factors differed between the test and control sites, these differences were evaluated and described.

Descriptive information was obtained from each site for the following:

- o Historical farming practices.
- o Fertilizer and pesticide application rates.

TABLE 3. TEST AND CONTROL SITES - REVISED SITE SAMPLING AND ANALYSIS PROGRAM (September, 1976)

Sample Type	Location	Sampling Frequency	Number of Samples	Constituents for Analysis	Number of Analyses per Site		
					Test	Control	Total
Soil	2 samples per site. Depths of 0-2, 2-4, 9-11, 29-31, 95-105 (10 sub-samples composited per sample), 195-205, and 295-305 cm.	1	14	Moisture and organic content, hydraulic conductivity, particle density, bulk density, particle size distribution. Soil pH (7)	98	98	196
Soil	2 samples per site. Depths of 0-2, 2-4, 9-11, 29-31, 95-105 (10 sub-samples composted per sample), 195-205 and 295-305 cm.	2 1st mo. and after 1 crop is harvested	28	CEC, extractable Soluble Salts (Ca, Mg, K, Na), P (as PO_4), N (as NO_3 and KjN), B, Cl, F, Cu, Ag, Hg, Pb, Cr, Cd, As, Ba, Mn, Mo, organic P, extractable P, Se, Zn; exchangeable cations (Ca, Mg, Na, K); extractable metals (Mg, As, Cu, Ag, Hg, Pb, Cr, Cd, Mn, Ni, Se, Zn); PCB, total and fecal coliform, protozoa, and nematodes (46)	1,288	1,288	2,576
				Total soils	1,386	1,386	2,772
Irrigation water	Treatment plant or main irrigation pipeline	2 x/month 13 months	26	TDS, coliform, fecal and total (3)	78	78	156

(continued)

TABLE 3 (continued)

Sample Type	Location	Sampling Frequency	Number of Samples	Constituents for Analysis	Number of Analyses per Site		
					Test	Control	Total
Irrigation water (Cont.)		Monthly composites of 2x/month samples, 13 times	13	P(as PO_4), NO_3, Ca, K, Pb, Na, Mg, Cl, F, Cr, Cd, Cu, B, As, Ba, Mo, Se, Zn, total N, TOC, TVOC, PCB, SO_4, Ni (24)	312	312	624
Groundwater	3 wells per site, each at 2 depths within the groundwater aquifer	2x/month at 2 depths within each well, 32 times	192	TDS, coliform, total and fecal (3)	576	576	1,152
		Monthly composites of 2x/month samples, 16 times	96	P(as PO_4), NO_3, Ca, K, Pb, Na, Mg, Cl, F, Cr, Cd, Cu, B, As, Ba, Mo, Se, Zn, total N, TOC, TVOC, PCB, SO_4, Ni, (24)	2,304	2,304	4,608
Lysimeter	3 places, 2 depths (150 & 300 cm became 50, 100, & 300 cm)	Composited at each depth 2x/month, 24 times	48	Same as irrigation water (3)	144	144	288
		Monthly composited at each depth	24	Same as irrigation water (24)	576	576	1,152
				Total water and moisture	3,990	3,990	7,980

(continued)

TABLE 3 (continued)

Sample Type	Location	Sampling Frequency	Number of Samples	Constituents for Analysis	Number of Analyses per Site		
					Test	Control	Total
Crops Control Sudan grass	3 sets of 5 composited plant samples of seeds and grain of 3 crops	1 each	9	Coliform, total and fecal (2)	-	18	18
Sorghum or wheat				NO_3, Ca, P, K, Na, Mg, Mo, Pb, Cr, Cd, Cu, B, Fe, As, Ba, Cl, S, Mn, Se, Zn (20)	-	180	180
Sorghum or other small grain							
Test	3 sets of 5 composited plant samples of green fodder or small grain of 4 crops	1 each	12	Coliform, total and fecal (2)	24	-	24
Sorghum				NO_3, Ca, P, K, Na, Mg, Mo, Pb, Cr, Cd, Cu, B, Fe, As, Ba, Cl, S, Mn, Se, Zn (20)	240	-	240
Sorghum or wheat							
Sorghum and milo				Total Crops	264	198	462
				Total Analyses	5,640	5,574	11,214

- Irrigation water source, quality, quantity, and frequency.
- Climatic data (wind, temperature, precipitation, etc.).
- Hydrogeology.
- Soil characteristics.
- Crop type, rotation, planting and harvesting dates, and yield.
- Farm worker health data.
- Crop market factors.

These data are presented in Appendix A, "Site Description."

SOIL SAMPLE COLLECTION

In accordance with the final program, soil samples were obtained prior to the first crop planting at the beginning of the monitoring, and after the last crop was harvested at the end of the monitoring. Soil samples were taken at seven depths (1-, 3-, 10-, 30-, 100-, 200-and 300-cm) and analyzed for the physical, chemical, and biological parameters indicated in Table 3. Ten sampling points were distributed uniformly throughout the area of each site for the shallow sampling (up to 100-cm). Deep samples (200-and 300-cm) were taken at two locations at each site where the drill rig and backhoe had access. Appropriate soil collection procedures were followed for biological, physical and chemical analyses as detailed below.

Biological and Chemical Sample Collection

Obtaining uncontaminated soil specimens for biological analysis proved to be a complex sampling procedure. Several methods were used to collect "clean" samples from seven depths at each location. Taking soil samples with a 15-cm diameter auger drill was found to be unacceptable due to the difficulty of preventing soils of different depths from intermixing during the collecting operation. Soil samples taken with a stainless steel, manually-operated probe were also subject to contamination during extraction. Trenching with a backhoe was found to be an effective means of obtaining good, clean samples at the test and control sites. Hence, 3-meter deep trenches were excavated at the desired locations and the selected depths were measured down the side wall of each trench. Approximately 2-cm of the exposed trench side wall was scraped away, using a disposable sterile spatula, to uncover the undisturbed soil. Next, the uncontaminated soil was transferred from inside each side wall location into a sterilized sample container using a second sterile spatula. During the sampling, it was determined that an undisturbed sample could also be easily obtained by removing a bucket of soil from the desired depth with a mechanical backhoe, and then taking the undisturbed biological soil specimen from the center of an unbroken clod of soil excavated at the desired depth. This technique was used to obtain the 200-and 300-cm soil samples because the unstable, sandy gravel subsoil made manual descent into a 3-meter deep trench hazardous.

Because unstable chemical compounds were also subject to time constraints, soil specimens for chemical analysis were ordinarily collected at the same time and in the same manner as the biological samples.

Once taken, samples were stored immediately in an ice chest and were refrigerated at 4° to 8° C until they were analyzed. Generally, all samples were composited in the laboratory and analyzed in accordance with recommended methods referenced in Appendix B. Biological examination was started within 24 hours after sample collection.

Physical Samples

Soil samples were also collected and physically analyzed for their density, moisture content, organic content, hydraulic permeability and particle size distribution. Shallow samples, 30-cm or less, were collected with hand tools. Deeper sampling employed a 15 cm diameter powered auger drill. Use of the drill, and standard methods for determining physical properties are further described in Appendix B.

LYSIMETER SAMPLES

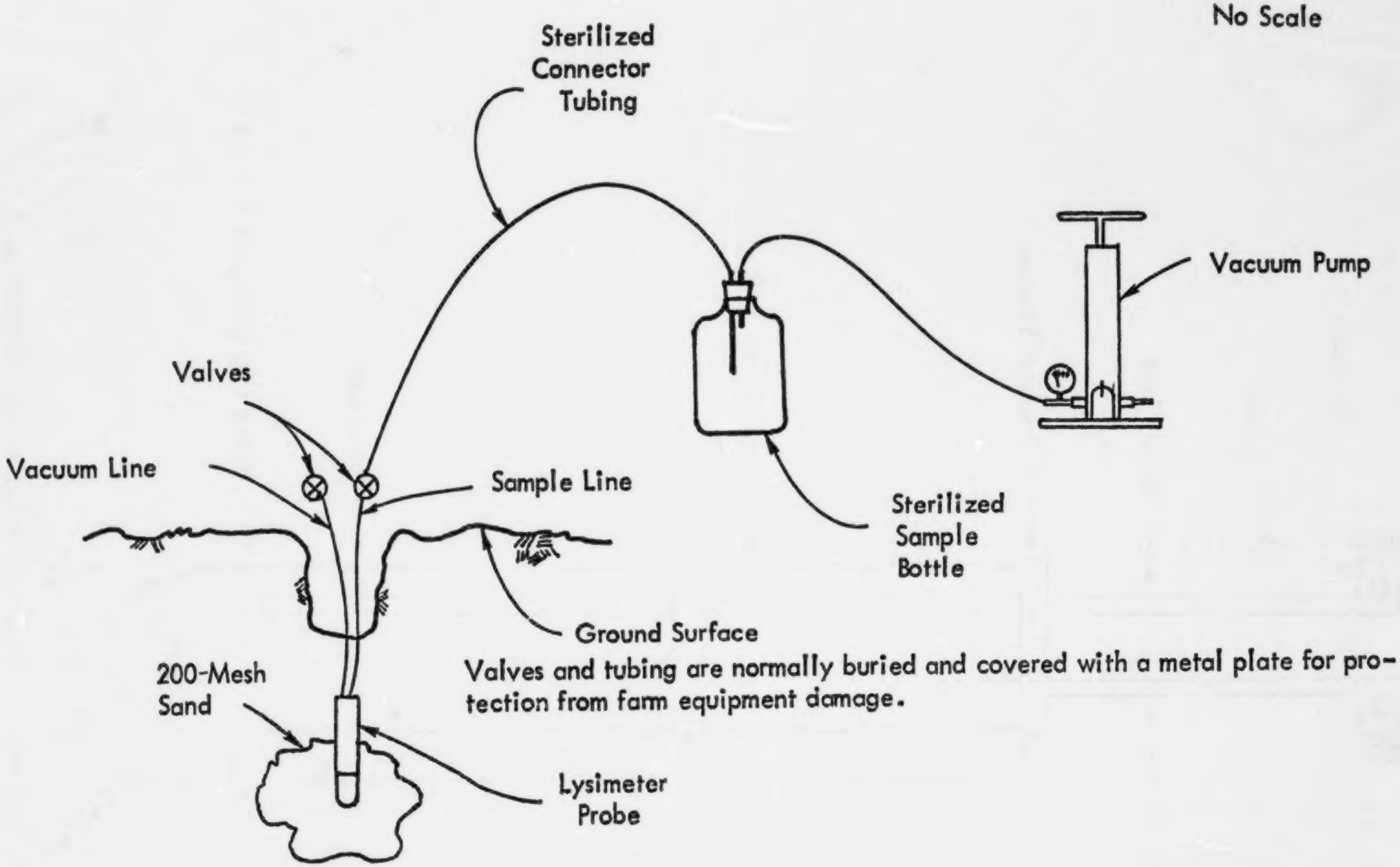
The leachate sampling program was designed to provide percolated water data at specific depths to allow comparison of chemical and biological balances and changes at both the test and control farm sites. The leachate was analyzed for the constituents itemized in Table 3. Figure 3 shows a schematic of the leachate sampling system.

Lysimeter Design

The lysimeters installed at the study sites were constructed using 60-cm sections of PVC, Class 125-psi, 5-cm O. D. pipe as shown in Figure 4. A 7 cm long by 4.7-cm diameter ceramic porous cup was attached to one end of the lysimeter probe pipe. The cups had a wall thickness of 0.23-cm with pore openings in the 1-2 μ range. The other end of the lysimeter probe pipe was fitted with a number 10 rubber stopper through which two 0.6-cm O. D. polyethylene tubes were extended. One polyethylene tube extended the length of the lysimeter probe and was used to remove collected leachate samples. The other tube terminated 1-cm below the rubber stopper and was used as a vacuum inlet for the lysimeter. Both tubes were fitted with gas-tight valves which controlled the internal vacuum and leachate sample flow.

Field Development

A series of field development tests were first carried out to determine the optimum vacuum conditions for the lysimeters. Figure 5 shows the amount of vacuum suction that was needed to extract leachate from the Mesa soils as a function of their percentage of


No Scale
Sterilized Connector Tubing
Vacuum Pump
Valves
Vacuum Line
Sample Line
Sterilized Sample Bottle
Ground Surface
200-Mesh Sand
Lysimeter Probe

Valves and tubing are normally buried and covered with a metal plate for protection from farm equipment damage.

Figure 3 . Sterile leachate sampler system schematic.

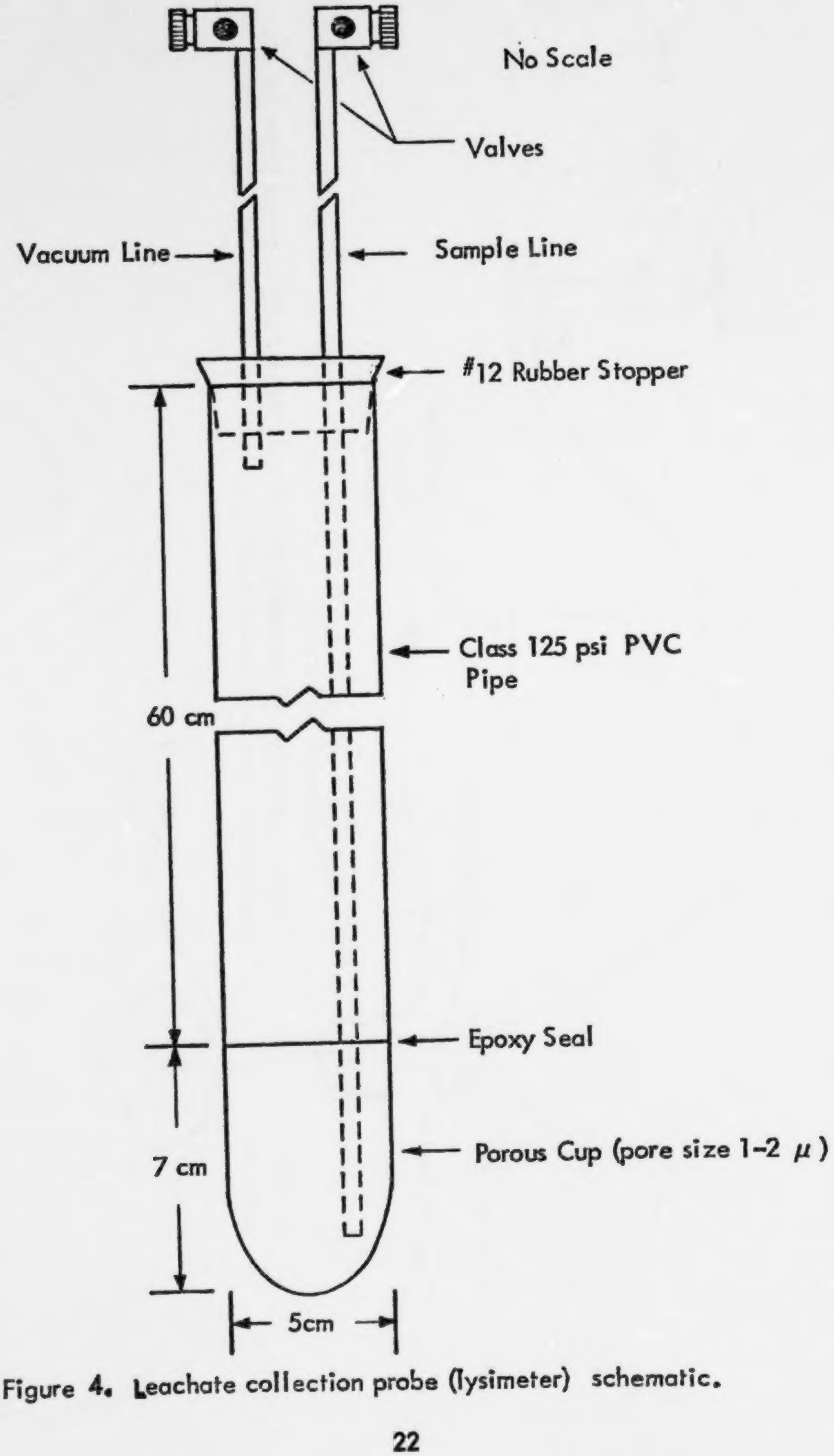

No Scale
Valves
Vacuum Line
Sample Line
#12 Rubber Stopper
Class 125 psi PVC Pipe
60 cm
Epoxy Seal
Porous Cup (pore size 1-2 μ)
7 cm
5cm

Figure 4. Leachate collection probe (lysimeter) schematic.

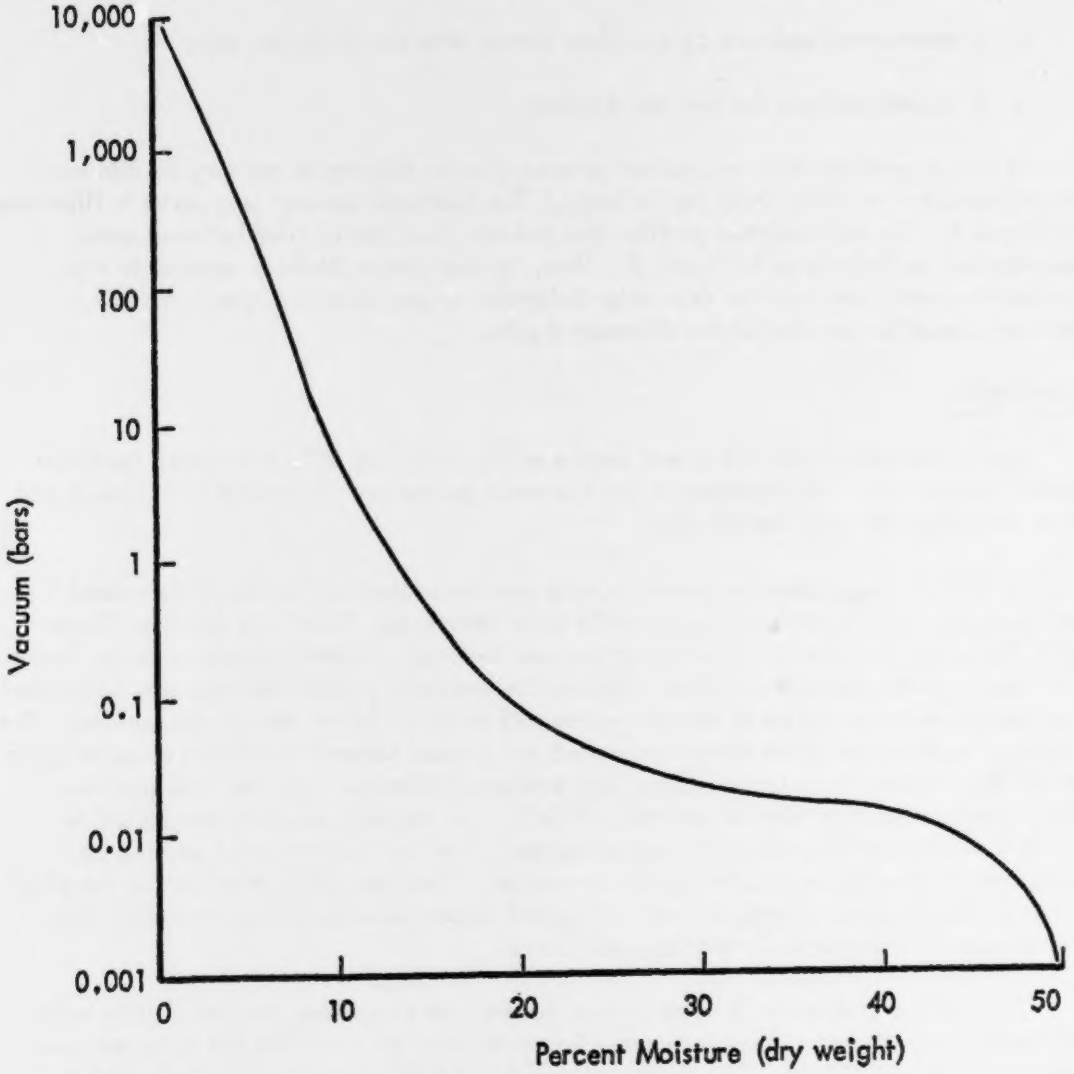


Figure 5. Lysimeter probe leachate collection and moisture release curves.

soil moisture. The soil moisture percentages in the agricultural topsoil were high enough for leachate collection, using a vacuum lysimeter, only immediately following irrigation or rainfall. The use of falling vacuum lysimeters avoided the expense of providing a continuously operating vacuum pump. This, however, necessitated embedding the porous cup in a slurry of 200-mesh sand. The sand slurry encasement served two purposes:

- It transported moisture by capillary action into the lysimeter cup.
- It helped prolong the vacuum duration.

It was determined that an applied vacuum of over 630-mm of mercury (0.838 bars) would remain at a useful level for 36 hours. The lysimeter vacuum loss curve is illustrated in Figure 6. The soil moisture profile changed as a function of time between water applications as illustrated in Figure 7. Thus, by applying a 36-hour vacuum to the lysimeters within one to three days after irrigation or precipitation, the peak soil moisture could be sampled at the different depths.

Installation

Lysimeters were installed at soil depths of 50; 100; and 300-cm at three locations within each field. The locations of the lysimeter probes are illustrated in Figures 8 and 9 for the Mesa test and control sites.

For the 300-cm deep lysimeter probe, a hole was excavated with a heavy duty mechanical auger drill rig or backhoe, and the hole bottom was filled to a depth of 20-cm with 200-mesh sand slurry. Then the probe was inserted, ceramic cup downwards, into the center of the slurry bed. After placing the lysimeter probe, the hole was backfilled and compacted with layers of the excavated soil to 60-cm below the ground surface. The sampling and vacuum lines were then coiled and placed beneath a protective metal plate at the 60-cm depth to protect against farm equipment damage, and the hole was then completely backfilled with native soil. Finally, the top soil was also compacted to prevent water from bypassing or channeling down into the lysimeter and causing an unrepresentative short-circuited leachate sample. Care was taken to minimize the alteration of the physical, chemical, and biological characteristics during the backfilling and to avoid interference in the farm operations.

The shallow lysimeters (50-and 100-cm depths) were installed somewhat differently. A trench approximately 90-cm long was excavated by hand shovel at the selected location to a depth of 100-cm. The lysimeter was then installed in this hole following the backfill procedure for the 300-cm depth probes described above. A second lysimeter, with its porous cup pointed downward and towards the 100-cm lysimeter probe, was then installed at an angle of 10° with respect to the horizontal in the original trench. The sample and vacuum lines were run back to the other end of the trench and covered with a metal plate. Next, the trench was completely backfilled. Lysimeters were evacuated after their initial installation. The initially collected water, which was introduced with the 200-mesh sand slurry, was extracted and disposed.

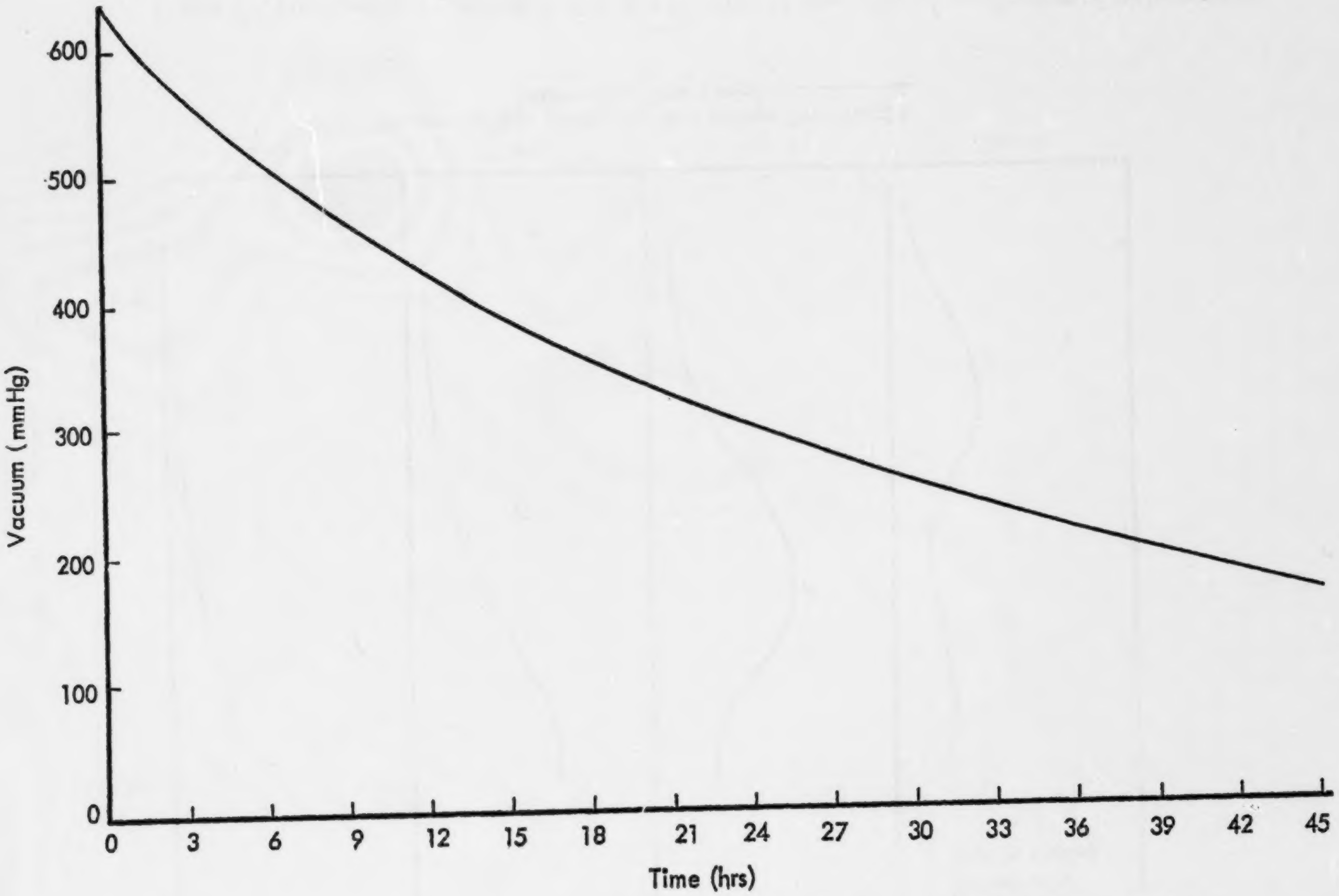


Figure 6. Falling vacuum lysimeter, vacuum dissipation with time.

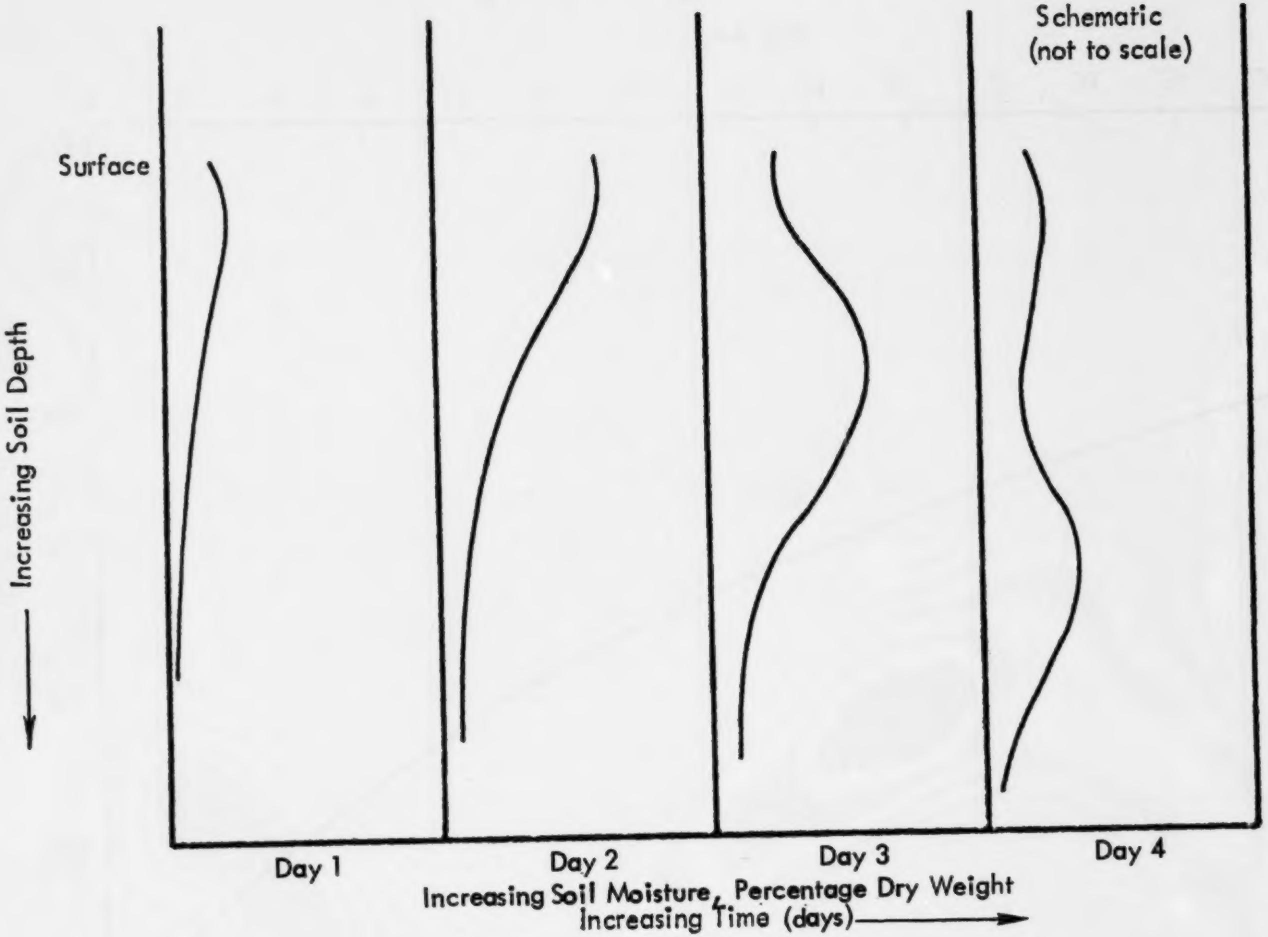

Schematic
(not to scale)
Surface
Increasing Soil Depth
Day 1
Day 2
Day 3
Day 4
Increasing Soil Moisture, Percentage Dry Weight
Increasing Time (days)

Figure 7 . Idealized soil moisture profile as a function of time after an application of surface water.

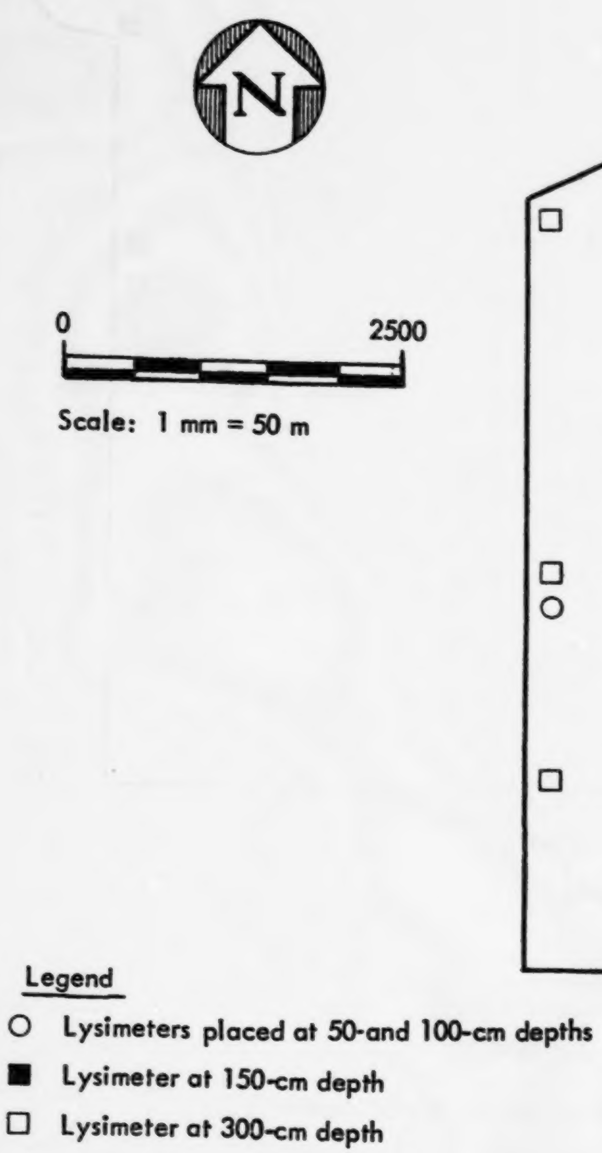
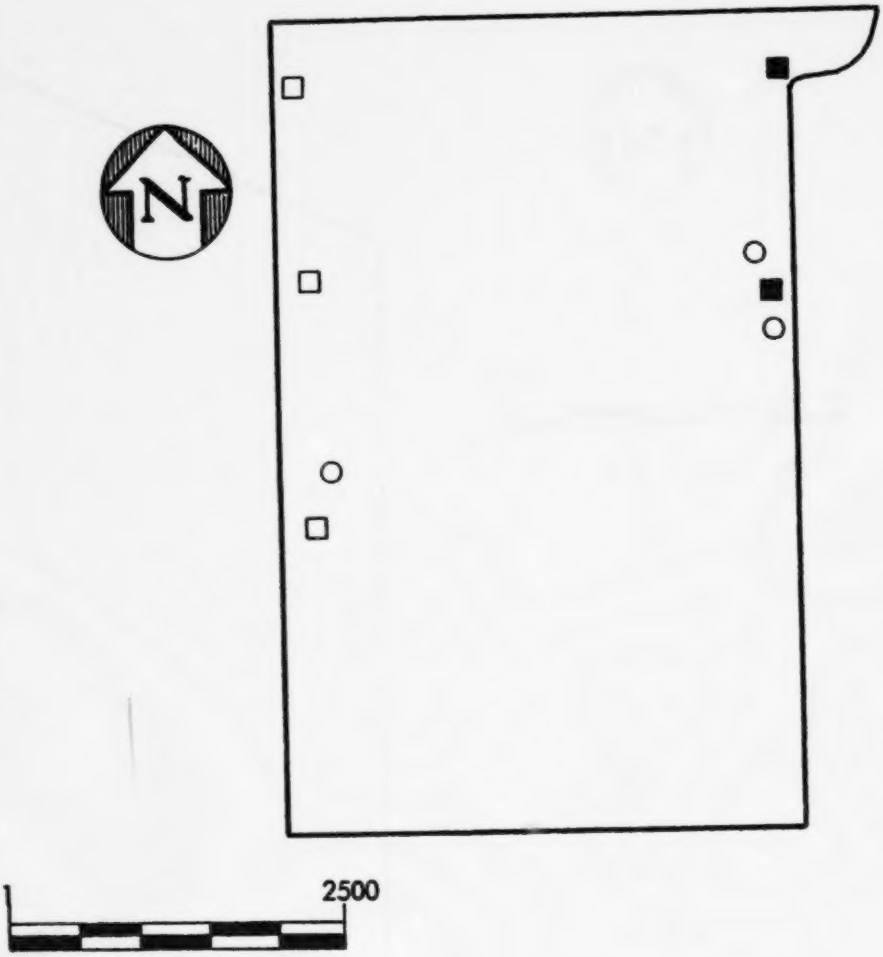

N
0
2500
Scale: 1 mm = 50 m
Legend
○ Lysimeters placed at 50-and 100-cm depths
■ Lysimeter at 150-cm depth
□ Lysimeter at 300-cm depth

Figure 8. Control site lysimeter locations.



Scale: 1 mm = 50 m

Legend

○ Lysimeters placed at 50-and 100-cm depths

■ Lysimeter at 150-cm depth

□ Lysimeter at 300-cm depth

Figure 9. Test site lysimeter locations.

Sampling Procedure

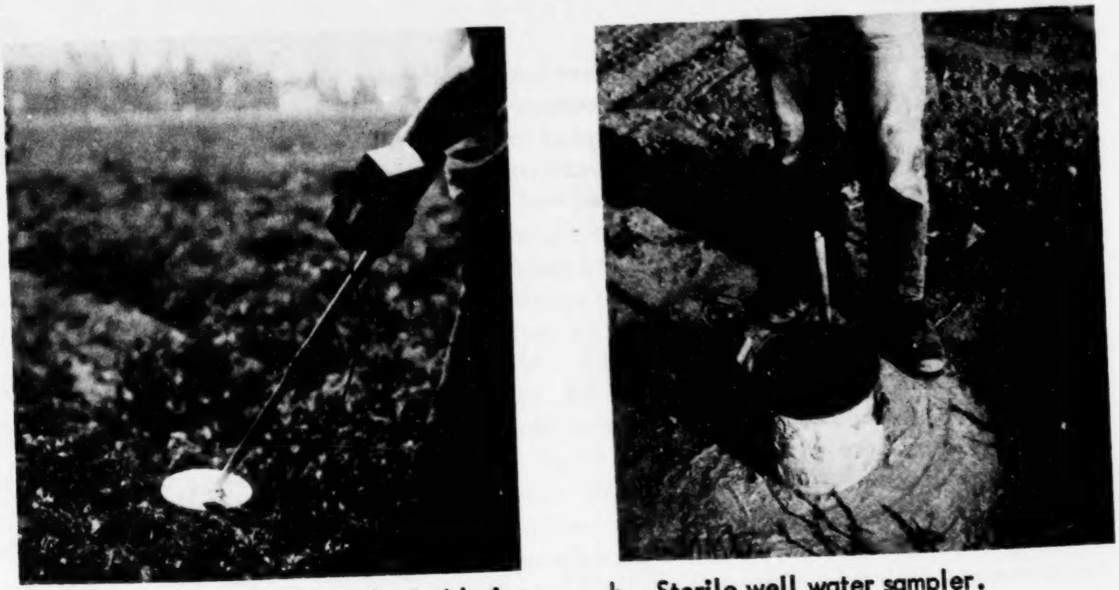
Initially, the lysimeter probes were evacuated following each field irrigation or natural precipitation to maximize the amount of leachate collected. Within two days of evacuation, the lysimeters were then sampled to remove all the collected leachate. To avoid non-representative reactions from occurring and to prevent readsorption of the sample by the soil as the vacuum dissipated and the 200-mesh sand encasement dried, the leachate sample was allowed to remain in the probe no longer than two days. Sterile collection procedures were used for all the samples. The leachate removal apparatus was sterilized each time before use to prevent contamination of bacteriological samples. Leachate samples were then removed via the lysimeter sampling probe using a hand-operated vacuum pump, as depicted in Figure 3. After sampling, the rubber stopper on the sample bottle was replaced with a sterile lid, each probe was re-evacuated, and the sample lines were reburied to protect against damage by farm equipment. Leachate samples were refrigerated at 4 - 8 °C in transit until time for the laboratory analyses. Bacteriological tests were started within 24 hours after the samples were collected. As the study progressed, the lysimeters were sampled and evacuated at two-week intervals. Occasionally, the shallow lysimeters were damaged during field plowing and required replacement. Figure 10 illustrates the field sampling.

Other investigators have reported erroneous nitrate and phosphate concentrations from analysis of leachate collected with porous ceramic cup lysimeters (2). Apparently NO_3 and PO_4 ions can be adsorbed onto the ceramic cup walls as they pass through. This effect was avoided by pretreating lysimeters in nitrate and phosphate solutions to reduce possible adsorption need. At the test and control sites, a number of lysimeters were installed which proved unproductive, probably because high soil porosity provided little retained moisture. The amount of leachate collected from these lysimeters was increased by using a much larger volume of 200-mesh sand bedding than used in the original lysimeters. The 3 standards and volume were increased approximately threefold to about 14 cubic decimeters for each ceramic lysimeter cup.

IRRIGATION WATER

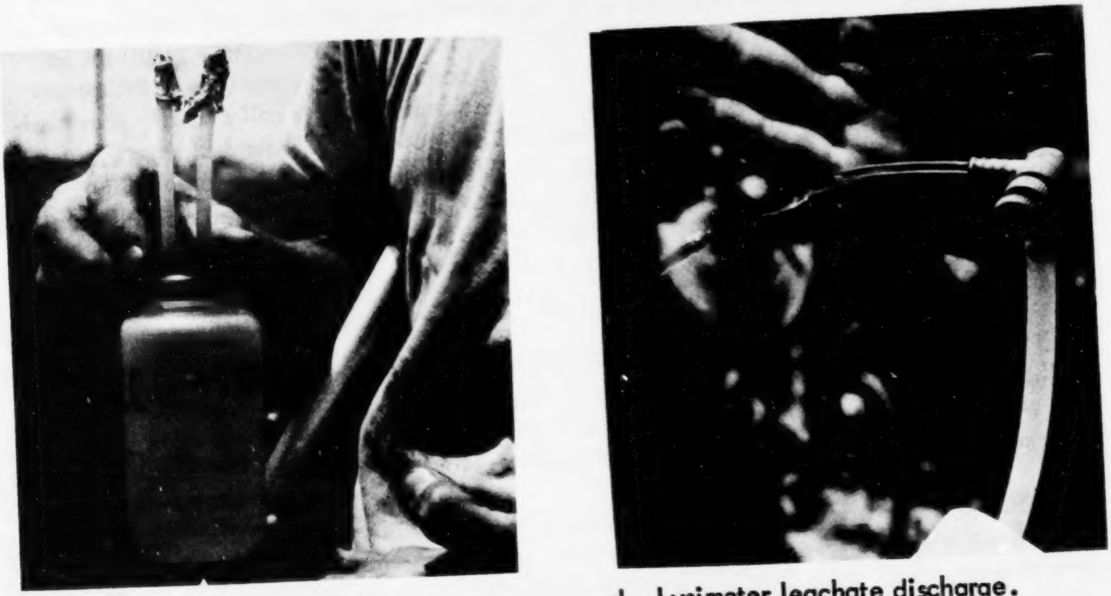
Undesirable constituents may be introduced into the soil and groundwater via the application of irrigation water. Analyses of this water provided significant baseline data from which to quantitatively determine the important constituents. The analyzed constituents are listed in Table 3. The sampling location is shown on Figure 11.

Effluent samples from the Mesa wastewater treatment plant were collected and composited daily by cooperating treatment plant personnel at the Mesa treatment plant,grab samples were taken daily from the irrigation effluent leaving the holding pond. The conventional irrigation water samples at the Mesa control site were obtained weekly from the Tempe Canal.



a. Metal detector to locate buried lysimeter.

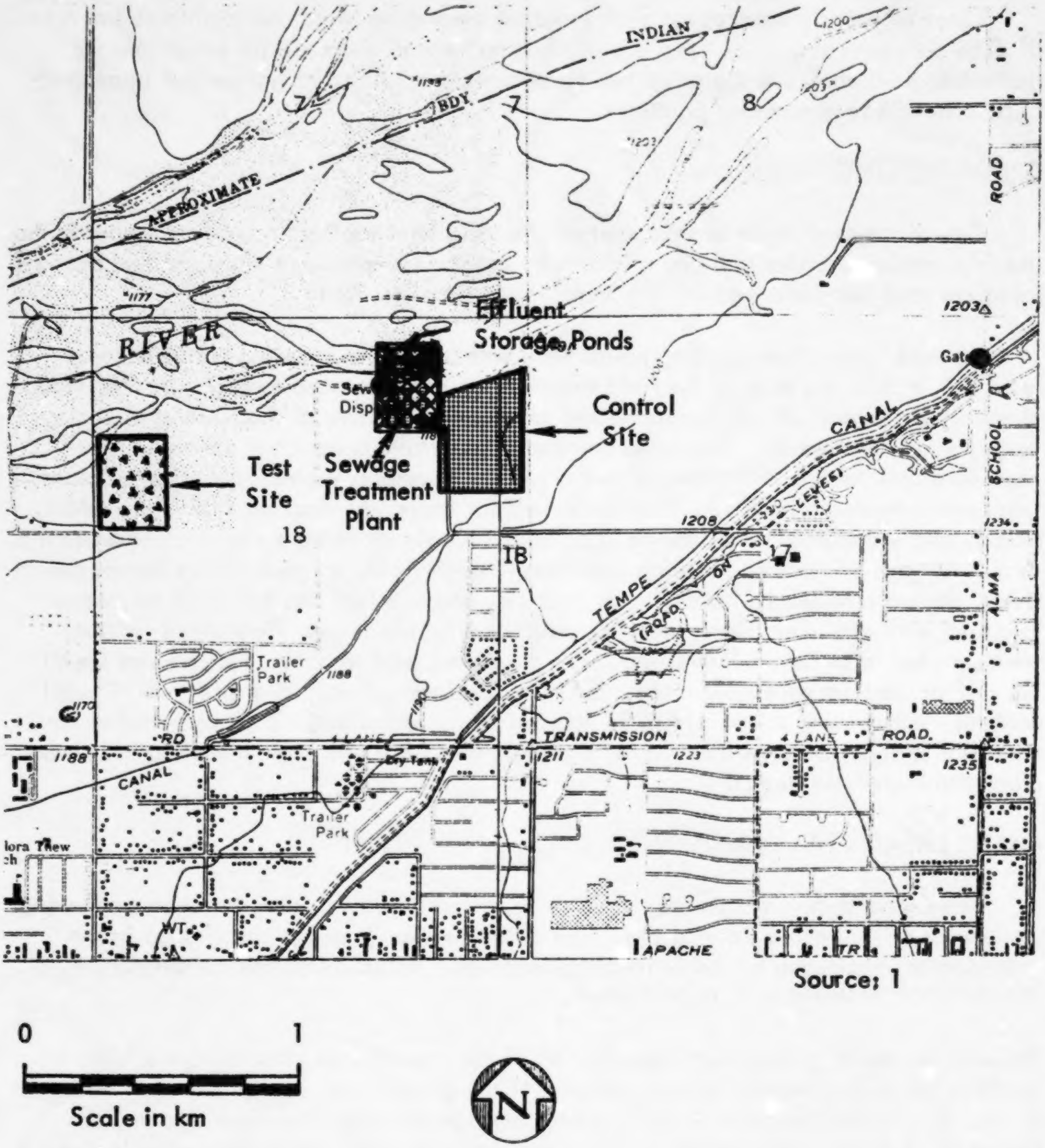
b. Sterile well water sampler.



c. Sterile lysimeter sampler.

d. Lysimeter leachate discharge.

Figure 10. Field sampling.


INDIAN
APPROXIMATE
BDY
7
7
8
1200
1203
1177
RIVER
Effluent Storage Ponds
Control Site
Test Site
Sewage Treatment Plant
18
18
17
Gate
1203
ROAD
CANAL
LEVEE
TEMPE
SCHOOL
ALMA
1208
1234
Trailer Park
1188
1170
RD
CANAL
4 LANE
TRANSMISSION
4 LANE ROAD.
1188
1211
1223
1235
Trailer Park
WT
APACHE
0
1
Scale in km
N

Source: 1

Legend

● Irrigation water sampling point

Figure 11. Irrigation sampling locations

Three bi-weekly samples for each location were composited and maintained at 4 to 8° C by refrigeration. One sample was taken and stored under sterile conditions for bacteriological analyses; the other two samples were acidified and preserved in accordance with EPA recommended practices.

CROP SAMPLING

One of the most important parameters affecting land application of wastewater is the possible uptake of undesirable constituents by crops. Quantitative chemical and bacteriological analyses performed on crop samples are listed on Table 3.

For each crop, five sampling points were selected. The sampling points were at least 7.5 m from the edge of the field and were uniformly spaced throughout. Individual plants were sampled only if they appeared to be representative of the field as a whol . Large, small, malformed, discolored or other unusual plants were not sampled. The procedure used for the collection of test plant tissue samples varied depending on plant types and intended analyses. Tissue specimens for bacteriological analyses were taken, stored, and transported under sterile conditions. Grain crops were sampled at harvesting time. At each of the five sampling locations in each field, samples of five leaves and five stalks were collected for chemical analysis, and one leaf and one stalk for bacteriological analysis. Ten blades were sampled for all grass crops. Fiber crops (cotton) were sampled once before harvesting. The procedure used to obtain samples was identical to that used for vegetable crops. These samples were maintained at 4 to 8° C until analysis, which commenced within 24 hours after tissue collection. Samples taken for chemical analysis were composited for digestion (see Appendix B for a description of the plant tissue analysis method).

GROUNDWATER WELL SAMPLING

Three groundwater monitoring wells were drilled at the test site, and two monitoring wells were drilled at the control site. The objective was to assess any change in the groundwater introduced by the infiltrating leachate. Table 3 lists the constituents for which chemical analyses were performed.

The criteria which governed the installation of the groundwater monitoring wells were: to place the wells upstream and downstream of the groundwater aquifer for each test or control site, where possible; to drill through stratigraphically identifiable formations and obtain samples, and to avoid faults where drainage water could short-circuit directly to the monitoring well; to minimize the impact of field well installation procedures on farming; and to construct sampling wells which were not to exceed 30.5 m in total depth with the lower 3 to 6 m placed in the uppermost aquifer yielding at least 15 lpm.

Data was obtained on soils and groundwater during the well drilling. In the test and control sites, a sandy topsoil layer was underlain by coarse alluvial material with some thin, clay interbeds (see Appendix A). Table 4 lists the depths to the water-bearing strata. Figure 12 shows wells and groundwater levels.

TABLE 4. MONITORING WELL DEPTHS

Site		Water-bearing Strata	Depths (m) Perforated Casing	Static Water Level	Water Elevation, M.S.L.
Mesa	MT-1[a]	32 - 36	30 - 36	26[d]	333[d]
	MT-2[b]	30 - 36	30 - 36	27	333
	MT-3[c]	31 - 36	30 - 36	30	329
	MC-1[a]	30 - 36	30 - 36	28[d]	333[d]
	MC-2[b]	41	28 - 41	32	331

[a] 2/24/77.
[b] 2/28/77.
[c] 4/8/77.
[d] 5/9/77.

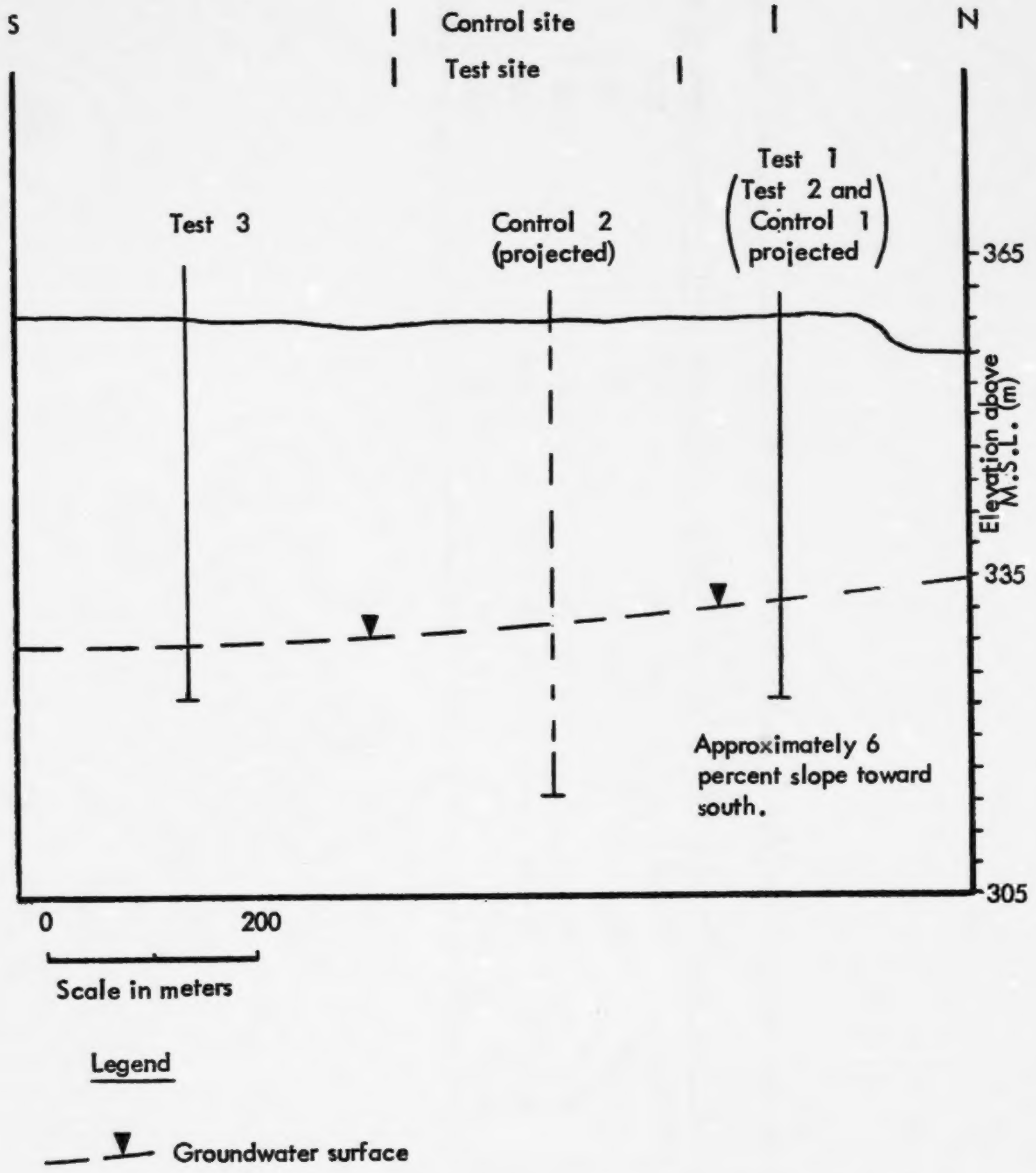

S
Control site
Test site
N
Test 3
Control 2 (projected)
Test 1
(Test 2 and Control 1 projected)
365
335
305
Elevation above M.S.L. (m)
Approximately 6 percent slope toward south.
0
200
Scale in meters
Legend
Groundwater surface

Figure 12. Mesa, Arizona idealized cross section showing wells and groundwater levels.

SECTION 6

WASTEWATER IRRIGATION EVALUATION

After the field sampling and analytical planning schedule (described in Section 5) was established, attention was directed toward full-scale implementation. The first soil and crop samples were collected during October and November, 1976. Lysimeters were installed for collection of leachate samples at all sites by December,1976. The groundwater monitoring wells were completed in March,1977.

The comprehensive irrigation water, soil, crop, leachate, and groundwater test program was performed from March,1977 through February,1978. The final set of soil samples was taken between October and December, 1977. Plant samples were collected whenever the crops were harvested. The analytical results and the evaluation of the soil, plant, and water studies are presented in this section.

Statistical comparisons were made of the test and control site analyses to test for any significant differences between conditions at the two locations. Three basic data conditions existed between the test and control sites: (1) the data were significantly different, (2) the data were similar, and (3) the data were below the analytical method detection limits, inconsistent or insufficient for determining any statistically significant difference or similarity. The following three statistical tests were employed to analyze the data: difference of means by the H-test (hypothesis test) or the student t-test, and the difference in variability by the chi-square distribution test. Detailed explanation of these statistical tests may be found in any statistics textbook. The difference of means was generally the main criteria used for determining if significant differences existed between the test and control sites. The t-test was used as the criteria for significance in the difference of means whenever the number of samples were small (usually less than 10 percent. The chi-square test was used to check the difference in variability between the test and control sites. The statistical tests were applied to complete the following data comparisons between the test and control sites:

- Control site irrigation water versus test site wastewater effluent.
- Leachate - comparison between test and control sites by depth.
- Groundwater - up to 30-meters depth below the ground surface; upstream, on-site, and downstream shallow groundwater samples were compared statistically for test and control sites separately.

- Soils – test versus control sites for initial and final samples; initial versus final test, and initial versus final control site samples.

The statistical analyses are presented in two data tabulations. The sample means, standard deviations, and statistical confidence levels (in percent) are given on one tabulation in Appendix E. The mean values and percentage difference in mean values between the test and control sites are summarized by confidence level categories in this section for each type of sample and/or sample location.

PHYSICAL CHARACTERISTICS OF SOILS

The physical soil baseline characteristics were determined from the set of samples taken in October, 1976; the results are shown in Table 5. The amount of organics present (see Figure 13, also) was greater in the control site samples (4.73 to 8.9 percent dry wt.) than in the test site samples (0.33 to 3.53 percent dry wt.) at all depths. This is believed to be due to the following reasons: the control site was harvested and the crop was plowed under just prior to sampling; the control site farmer applied manure, whereas the test site farmer did not; and the composition of the control site soils was somewhat finer, containing a more silty material, when compared to the more sandy soils of the test site. The moisture content, illustrated by depth in the curves in Figure 14 for both the test and control site soils, generally increased with depth.

BIOLOGICAL AND CHEMICAL CHARACTERISTICS OF WATER AND SOILS

Irrigation Water Analyses

The irrigation and wastewater statistical results are given in Table 6. The results shown in Table 6 compare the mean and the percentage difference of the mean of the irrigation waters. The test effluent was significantly higher (96 to 99 percent confidence levels) in total dissolved solids. The major contribution to the dissolved solids were chlorides, which were 40 percent higher in the test effluent, and sodium, which was higher by 43 percent. Other ions, generally considered as dissolved solids, such as magnesium and calcium, were not significantly different between the test and control irrigation waters. Potassium, another component of the dissolved solids, but also a nutrient, was higher in the test effluent by 180 percent at a 96 to 99 percent significance level. Other nutrients also significantly higher at the 96 to 99 percent level in the test effluent were: total nitrogen, by 600 percent, and phosphates by more than 1,700 percent. Thus, the test effluent provided substantial fertilization to the crops grown on the test site. No significant difference was found in the trace metals between the test and control irrigation waters. Based on these results, metal contamination of the test site soils or crops should not occur. Even though differences, significant at the 96 to 99 percent level, were not statistically identified for total and fecal coliform between the test and control sites' irrigation water, the test site coliform populations were on the order of five thousand times higher in the test site effluent.

TABLE 5. SOIL PHYSICAL CHARACTERISTICS[a]

Horizon (cm)	USDA Classification[b]	Particle Density (g/cc)	Dry Bulk Density (g/cc)	Hydraulic Conductivity (cm/sec x 10^{-4})	Moisture Content (% dry wt.)	Organic Content (% dry wt.)
Test						
1	Sandy loam, sandy clay loam	2.51	1.59	4.30	1.73	3.30
3	Same as above	2.53	1.45	5.77	7.36	3.53
10	Same as above	2.34	1.49	5.17	11.97	3.30
30	Same as above	2.54	1.54	4.90	10.90	1.97
100	Sand, sandy clay loam	2.38	1.53	7.73	11.60	3.35
200	Same as above	2.64	1.68	32.7	13.05	0.93
300	Same as above	2.17	--[c]	--	5.53	0.33
Control						
1	Clay loam, silty clay loam	2.38	1.36	0.12	4.85	8.07
3	Same as above	2.41	1.41	0.23	5.87	8.90
10	Same as above	2.57	1.42	1.59	8.41	8.13
30	Clay loam, silty loam, silty clay loam	2.59	1.48	1.03	10.23	7.63
100	Silty clay loam, sandy clay loam	2.54	1.48	0.36	12.83	6.47
200	Silty clay loam	2.60	1.51	0.39	19.65	4.73
300	Sandy clay loam, silty loam	2.28	1.54	12.5	23.45	4.73

[a] As averages of different boreholes.
[b] Varying soil types are for different boreholes.
[c] Not determined.

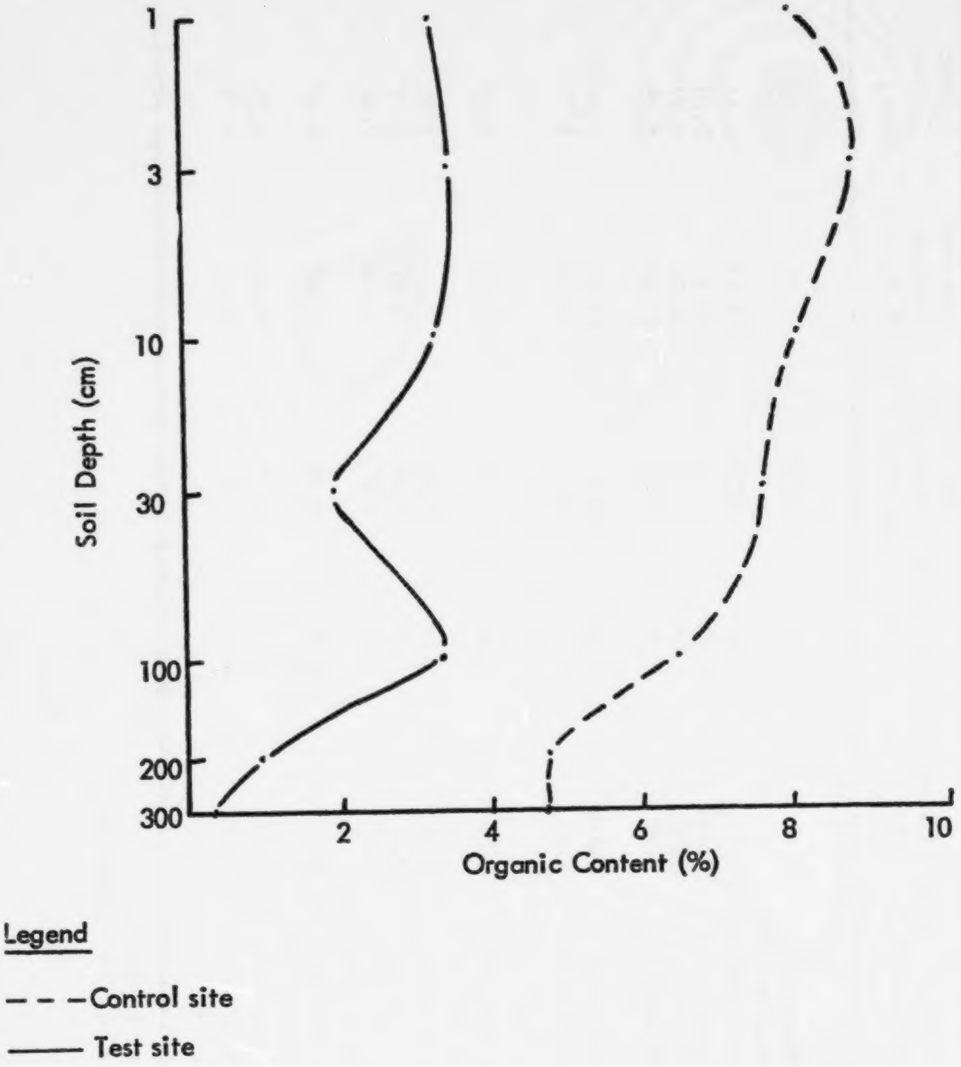


Figure 13. Soil organic content

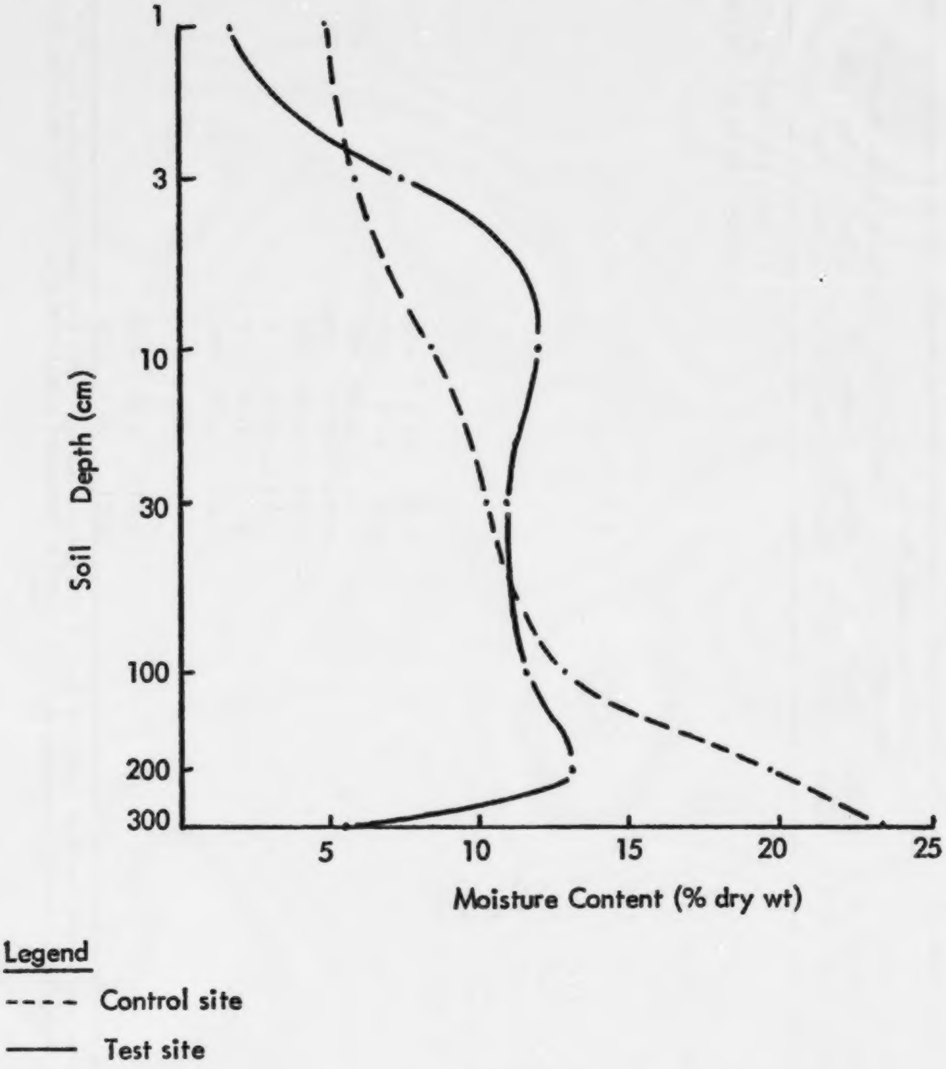


Figure 14. Soil moisture content.

TABLE 6 . STATISTICAL SUMMARY OF IRRIGATION WATER

Constituent	Significance Level, Percent 96 - 99% Mean Control	 96 - 99% Values[b] Test	 96 - 99% % [c] Diff.	 90 - 95% Mean Control	 90 - 95% Values Test	 90 - 95% % Diff.	 Less than 90% Mean Control	 Less than 90% Values Test	 Less than 90% % Diff.	Questionable Results[a] Mean Control	 Value Test	 % Diff.
TC										11,300	3.09×10^6	27,000
FC										1,030	1.05×10^5	10,000
TDS	818	1044	+27									
B	0.19	0.44	+130									
Cl	254	356	+40									
F	0.50	1.41	+182									
NO_3 - N							2.7	1.8	-38			
TN	3.5	24.9	+600									
TOC	19.9	58.9	+200									
PO_4-P	0.5	9.0	+1740									
SO_4	54	67	+24									
K	6.4	18.1	+181									
Na	150	215	+43									
Ca							42.5	46.8	+10			
Mg							37.4	41.8	+12			
Ba							0.13	0.16	+23			
Cd							0.01	0.02	+100			
Cr							0.03	0.04	+33			
Cu							0.08	0.08	0			
Mo							0.10	0.10	0			
Ni							0.05	0.07	+40			
Pb										0.06	0.06	
Zn												
As							0.01	0.02	+100			
Se							0.01	0.01	0			

[a] Indeterminate because values were less than detection limit.

[b] The average value, in mg/kg, of results from seven depths.

[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.

Leachate Analyses

Comparisons were statistically made between the test and control site lysimeter leachate samples at 50-and 100-cm depths. The data is presented in Tables 7 and 8. The statistical analyses were based on the student t-test rather than the H-test, because the number of samples varied from zero to two at the control site, and three to seven at the test site. The results indicated that the differences between test and control site lysimeter samples at 50-cm depth were not significant (below the 90 percent level). At the 100-cm depth, only the total coliform was significantly lower (95 to 99 percent confidence level) at the test site, and the test and control site lysimeters showed that the test site was probably (90 to 95 percent level) lower for magnesium and nickel. Several samples showed questionable differences as a result of having no values for the control site leachate because of insufficient sample volumes. The low significance levels were attributed, in part, to the small number of samples. Highly reliable statistical results were thus not possible between the test and control leachates because of the low number of samples. Few samples were collected because of lysimeter damage by farming.

To further evaluate the difference between the two sites, the mean values for each irrigation water and wastewater leachate constituent were listed according to depth, in Table 9, with the irrigation waters designated as zero depths. For both sites, the total and fecal coliform counts found in the irrigation waters were reduced by more than 99.5 percent by percolation to the 100-cm depth. Thus, land treatment of the treated effluent appeared to be effective in reducing potential pathogenic organisms to near the detectable limits after percolation through a 100-cm soil depth. The total solids increased with depth at both sites, but at different rates. During the first 50 cm, the control site leachate increased 50 percent in total dissolved solids, and then decreased almost to the irrigation water level at the 100-cm depth. The test site leachate also increased and then decreased in total dissolved solids with depth, but not as greatly as the control site leachate. The decrease in total dissolved solids from the 50-to 100-cm depth may have been due to the change in the type (classification) of soil (see Table 5).

The major components of the total dissolved solids, sodiums, and chlorides increased in concentration between zero-and 50-cm depth and, except for sodium at the test site, decreased at the 100-cm depth (see Table 9). Nitrates increased with depth at the control site by about 570 to 590 percent. The test site nitrates increased at the 50-cm depth by about 3200 percent. The potassium content at the control site increased while the test leachate concentration remained relatively unchanged. The increase at the control site was most likely related to the increase in total dissolved solids, but definitely not to the added fertilizer which contained only nitrogen and phosphorus. The phosphate content increase at the control site was attributed to fertilizer added during the monitoring program. The test effluent, which contained nearly 2,000 percent more phosphate than the control irrigation water, was the only supplier of nutrients to the test site. Consequently, a decrease in phosphate at the test site was expected due to soil fixation and crop uptake. Most of the metal concentrations remained nearly the same during the percolation; the only major exception was zinc which increase by 600 percent (0.06 at

TABLE 7. STATISTICAL SUMMARY OF 50-CM LYSIMETER

Significance Level, Percent

Constituent/ Form	Less than 90% Mean Control	Values Test	% Diff.	Questionable Results[a] Mean Control	Value Tests	% Diff.
TC	20[d]	<2	-90			
FC	<2	<2	0			
TDS	1,242[d]	1,507	+21			
B	0.45[d]	0.34	-24			
Cl	486[d]	380	-22			
F				--	0.85	--
NO_3-N						
TN				--	54.7	--
TOC				--	8.3	--
PO_4-P	1.0[d]	5.0	400			
SO_4	144[d]	110	-24			
K				--	15.0	--
Na	285[d]	222	-22			
Ca				--	70.8	--
Mg				--	51.0	--
Ba				--	0.22	--
Cd	0.01[d]	0.01	0			
Cr	0.03[d]	0.02	-33			
Cu				--	0.06	--
Mo				--	0.10	--
Ni	0.09[d]	0.05	-44			
Pb	0.12[d]	0.07	-42			
Zn	0.32[d]	0.19	-41			
As	0.01[d]	0.01	0			
Se	0.01[d]	0.01	0			

[a] Indeterminate because values were less than detection limit.

[b] The average value in mg/kg of results from seven depths.

[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.

[d] Difference of mean shows 95 to 99 percent confidence level that the difference between the means is significant; whereas the T-test shows that the difference is insignificant. (See Appendix D for actual data.)

TABLE 8. STATISTICAL SUMMARY OF 100-CM LYSIMETER

Constituent/ Form	Significance Level, Percent									Questionable Results[a]		
	96 - 99%			90 - 95%			Less than 90%					
	Mean Values[b] Control	Test	%[c] Diff.	Mean Values Control	Test	% Diff.	Mean Values Control	Test	% Diff.	Mean Value Control	Test	% Diff.
TC	60	9	-85									
FC							25	9	-64			
TDS										888	1,342	+51
B							0.22	0.48	+118			
Cl							354	316	-11			
F							1.06	1.10	+4			
NO_3-N										18.5	50.5	+173
Tn										19.3	46.4	+140
TOC										--	16.1	--
PO_4-P							3.6	4.2	+17			
SO_4										84	176	+110
K							15.6	15.6	0			
Na							211	306	+45			
Ca										23.0	102	+343
Mg				61.1	39.7	-36						
Ba							0.18	0.16	-11			
Cd							0.01	0.02	+100			
Cr							0.05	0.05	0			
Cu							0.16	0.06	-63			
Mo							0.10	0.10	0			
Ni				0.31	0.10	-68						
Pb							0.09	0.06	-33			
Zn	0.37	0.16	-57									
As							0.01	0.01	0			
Se							0.01	0.01	0			

[a] Indeterminate because values were less than detection limit.
[b] The average value in mg/kg of results from seven depths.
[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.

TABLE 9. COMPARISON OF IRRIGATION WATER AND LEACHATE ACCORDING TO DEPTH[a]

Depth (cm)	Total Colif.[b] Cont.	Total Colif.[b] Test	Fecal Colif.[b] Cont.	Fecal Colif.[b] Test	TDS Cont.	TDS Test	B Cont.	B Test	Cl Cont.	Cl Test	F Cont.	F Test	NO_3-N Cont.	NO_3-N Test	TN Cont.	TN Test
0	1.1×10^4	3.0×10^6	1.0×10^3	1.0×10^5	818	1,044	0.19	0.44	254	356	0.5	1.4	2.7	1.8	3.5	24.9
50	20	< 2	<2	<2	1,242	1,507	0.45	0.34	486	380	--	0.85	18.0	59.4	--	54.7
100	60	9	25	9	888	1,342	0.22	0.48	354	316	1.1	1.1	18.5	50.5	19.3	46.4
Level of Confidence - % (correlation coefficient)	99		99		< 80		<80		<80		--		85		--	

Depth (cm)	TOC Cont.	TOC Test	PO_4-P Cont.	PO_4-P Test	SO_4 Cont.	SO_4 Test	K Cont.	K Test	Na Cont.	Na Test	Ca Cont.	Ca Test	Mg Cont.	Mg Test	Ba Cont.	Ba Test
	19.9	58.9	0.5	9.0	54	67	6.4	18.1	150	215	42.5	46.8	37.4	41.8	0.13	0.16
	--	8.3	1.0	5.0	144	110	--	15.0	285	222	--	70.8	--	51.0	--	0.22
	--	16.1	3.6	4.2	84	176	15.6	15.6	211	306	23	102	61.1	39.4	0.18	0.16
	--		<80		< 80		--		<80		--		--		--	

Depth (cm)	Cd Cont.	Cd Test	Cr Cont.	Cr Test	Cu Cont.	Cu Test	Mo Cont.	Mo Test	Ni Cont.	Ni Test	Pb Cont.	Pb Test	Zn Cont.	Zn Test	As[c] Cont.	As[c] Test
	0.01	0.02	0.03	0.04	0.08	0.08	0.10	0.10	0.05	0.07	0.05	0.08	0.06	0.06	0.01	0.02
	0.01	0.01	0.03	0.02	--	0.06	--	0.10	0.09	0.05	0.12	0.07	0.32	0.19	0.01	0.01
	0.01	0.02	0.05	0.05	0.16	0.06	0.10	0.10	0.31	0.10	0.09	0.06	0.37	0.16	0.01	0.01

[a] Values reported as mg/l, unless otherwise noted.

[b] Values reported as MPN/100 ml.

[c] All values for selenium are the same as arsenic values except that the test at zero depth was 0.01 mg/l Se.

zero cm to .37 mg/l at 100 cm) at the control site and by nearly 200 percent (0.06 at zero depth to 0.16 mg/l at 100 cm, at the test site.

Groundwater Analyses

The samples from upstream, on-site, and downstream wells at the test and control sites were statistically compared to evaluate changes in groundwater quality from wastewater irrigation. The statistical analyses are summarized in Tables 10 to 15.

Control well 1 was located on the upstream edge of the site; therefore, this well was considered free of any potential contaminants resulting from the irrigation water. The statistical comparisons between control wells 1 and 2 are given in Tables 10 and 11 for the upper and lower well levels, respectively. Increases, at the 96 to 99 percent confidence level, were found in control well 2, at both depths, for total dissolved solids (increases of 36 and 29 percent for upper and lower sampling, respectively), chlorides (34 and 37 percent), sulfate (77 and 66 percent), and sodium (63 and 59 percent). There were no significant differences in the other constituents between the upper levels of the control wells 1 and 2. The lower level of control well 2 showed a probable significant (90 to 95 percent confidence level) decrease in barium by 18 percent and an 80 percent increase in nitrate concentration. Based on the student t-test, the difference in the nitrate was not significant. No significant differences were found in total or fecal coliform between control site wells 1 and 2 at the upper and lower level. The major significant difference in well water quality detected downstream of the control site was the salt content. This was expected since the irrigation water was high in dissolved salts, and the leachate picked up salt during percolation through the soils.

The upstream test well 1 and downstream test well 3 are compared in Tables 12 and 13. Significant increases, at the 96 to 99 percent confidence level, were found at both the top and bottom test well 3 groundwater samples for total dissolved solids, by 56 and 63 percent; chlorides, by 45 percent; sodium, by 44 percent and 37 percent; calcium by 94 and 90 percent; and magnesium, by 118 and 110 percent. The total dissolved solids increase in the downstream test well 3 was attributed to high levels of sodium chloride in the test site effluent plus leaching of salts from the soil. Calcium and magnesium increased significantly, also as a result of leaching from the soil. Boron increased significantly by 88 and 110 percent at the upper and lower levels, respectively. Probable significant increases at the 90 to 95 percent confidence level were found for nitrates (by 74 and 71 percent) and total nitrogen (by 67 percent) at both well levels, and sulfate (by 27 percent) at the top level. Thus, the nitrate, a nutrient source, effectively passed through the soil. Total coliform was significantly lower, at the 96 percent level in the upper level, downstream from test well 1, which emphasizes the fact that coliform are effectively removed by the soil. The remaining constituents, including all the heavy metals, did not differ significantly between the upstream and downstream well 3; therefore, heavy metals were not a problem and did not contaminate the groundwater. Also, significant quantities of organic content, measured by the total organic carbon, did not leach through the soil to contaminate the groundwater. Hence,

TABLE 10 STATISTICAL SUMMARY OF CONTROL WELL TOP SAMPLES: ON-SITE (1) VS. ON-SITE (2)

Constituent/ Form	Significance Level, Percent 96 - 99% Mean Values[b] Wells (1)	(2)	%[c] Diff.	90 - 95% Mean Values Wells (1)	(2)	% Diff.	Less than 90% Mean Values Wells (1)	(2)	% Diff.	Indeterminable Results[a] Mean Value Wells (1)	(2)	% Diff.
TC							47	76	+62			
FC										< 2	< 2	
TDS	1,016	1,380	+36									
P							0.47	0.41	-13			
Cl	298	398	+34									
F							0.46	0.68	+48			
NO_3-N							4.5	5.7	+27			
TN							6.0	7.5	+25			
TOC							30.6	33.9	+11			
PO_4-P							1.5	0.5	-67			
SO_4	66	117	+77									
K							9.4	10.0	+6			
NC	177	288	+63									
Ca							63	58	-8			
Mg							73	91	+25			
Ba							0.20	0.17	-15			
Cd							0.01	0.01	0			
Cr							0.03	0.03	0			
Cu							0.04	0.06	+50			
Mo							0.10	0.11	+60			
Ni							0.05	0.05	0			
Pb							0.32	0.15	-52			
Zn							0.31	0.18	-42			
As							0.02	0.01	-50			
Se							0.01	0.01	0			

[a] Indeterminate because values were less than detection limit.
[b] The average value in mg/kg of results from seven depths.
[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-"sign) over the control.

TABLE 11. STATISTICAL SUMMARY OF CONTROL WELL BOTTOM SAMPLES: ON-SITE(1) VS. ON-SITE (2)

Constituent/ Form	Significance Level, Percent											
	96 - 99%			90 - 95%			Less than 90%			Questionable Results[a]		
	Mean Values[b] Wells (1)	Mean Values[b] Wells (2)	%[c] Diff.	Mean Values Wells (1)	Mean Values Wells (2)	% Diff.	Mean Values Wells (1)	Mean Values Wells (2)	% Diff.	Mean Value Wells (1)	Mean Value Wells (2)	% Diff.
TC										1,880	44	-98
FC							6	4	-33			
TDS	1,055	1,360	+29									
B				0.49	0.40	-18						
Cl	308	423	+37									
F							0.52	0.64	+23			
NO_3-N				4.6	8.3	+80						
TN							6.6	10.2	+55			
TOC							21.7	24.9	+15			
PO_4-P							0.7	0.4	-43			
SO_4	68	113	+66									
K							9.5	11.0	+16			
Na	165	262	+59									
Ca							60	76	+27			
Mg							74	96	+30			
Ba							0.22	0.16	-27			
Cd							0.01	0.01	0			
Cr							0.03	0.03	0			
Cu							0.06	0.08	+33			
Mo							0.11	0.10	-9			
Ni							0.05	0.06	-20			
Pb							0.13	0.09	-31			
Zn							0.26	0.18	-31			
As							0.01	0.02	+100			
Se							0.01	0.01	0			

[a] Indeterminate because values were less than detection limit.

[b] The average value in mg/kg of results from seven depths.

[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.

TABLE 12. STATISTICAL SUMMARY OF TEST WELL TOP SAMPLES: UPSTREAM (1) VS. DOWNSTREAM (3)

Constituent/ Form	Significance Level, Percent: 96 - 99% Mean Values[b] Wells (1)	96 - 99% Mean Values[b] Wells (3)	96 - 99% %[c] Diff.	90 - 95% Mean Values Wells (1)	90 - 95% Mean Values Wells (3)	90 - 95% % Diff.	Less than 90% Mean Values Wells (1)	Less than 90% Mean Values Wells (3)	Less than 90% % Diff.	Questionable Results[a] Mean Value Wells (1)	Questionable Results[a] Mean Value Wells (3)	Questionable Results[a] % Diff.
TC	145	46	-68									
FC										2	1.33	Indet.
TDS	728	1,135	+56									
B	0.32	0.6	+88									
Cl	234	340	+45									
F							0.43	0.42	-2			
NO_3-N				6.9	12.0	+74						
TN				9.1	15.2	+67						
TOC							18.9	26.1	+38			
PO_4-P							1.0	1.7	+70			
SO_4				66	84	+27						
K							7.6	9.0	+18			
Na	158	228	+44									
Ca	31	60	+94									
Mg	36	78	+118									
Ba							0.15	0.24	+60			
Cd							0.01	0.01	0			
Cr							0.02	0.03	+50			
Cu							0.08	0.07	-13			
Mo							0.12	0.12	0			
Ni							0.05	0.05	0			
Pb							0.19	0.14	-26			
Zn							0.18	0.22	+22			
As							0.02	0.02	0			
Se							0.01	0.01	0			

[a] Indeterminate because values were less than detection limit.

[b] The average value in mg/kg of results from seven depths.

[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-"sign) over the control.

TABLE 13. STATISTICAL SUMMARY TEST WELL BOTTOM SAMPLES: UPSTREAM (1) VS. DOWNSTREAM (3)

Constituent/ Form	Significance Level, Percent: 96 - 99% Mean Values[b] Wells (1)	Wells (3)	%[c] Diff.	90 - 95% Mean Values Wells (1)	Wells (3)	% Diff.	Less than 90% Mean Values Wells (1)	Wells (3)	% Diff.	Questionable Results[a] Mean Value Wells (1)	Wells (3)	% Diff.
TC										874	94	-89
FC							3	<2	≥- 33			
TDS	734	1,193	+63									
B	0.29	0.61	+110									
Cl	247	357	+45									
F							0.34	0.79	-132			
NO_3-N				5.8	9.9	+71						
TN	7.11	11.9	+67									
TOC							31.3	31.1	-1			
PO_4-P							1.2	2.1	+75			
SO_4							72	78	+8			
K							8.4	11.7	+39			
Na	158	217	+37									
Ca	31	59	+90									
Mg	40	84	+110									
Ba							0.16	0.19	+19			
Cd							0.01	0.01	0			
Cr							0.03	0.03	0			
Cu							0.08	0.07	-13			
Mo							0.11	0.10	-9			
Ni							0.05	0.05	0			
Pb							0.13	0.19	+46			
Zn							0.32	0.26	-19			
As							0.03	0.02	-33			
Se							0.01	0.01	0			

[a] Indeterminate because values were less than detection limit.
[b] The average value in mg/kg of results from seven depths.
[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.

the soil acted as a tertiary treatment for removing organic and bacterial content.

The upstream test well 2, located closer to the test site than the upstream test well 1, was also statistically compared with the downstream, test well 3. The statistical summary is presented in Tables 14 and 15. The following constituents were significantly (at the 96 to 99 percent confidence level) greater downstream from test well 2: total dissolved solids (by 63 and 60 percent at the top level and at the bottom level, respectively), chlorides (by 52 and 55 percent), sodium (by 44 and 39 percent), calcium (by 71 and 104 percent), and magnesium(by 78 and 99 percent). Thus, the increased salt content from the test effluent and the salts extracted from the soil contaminated the groundwater. The total and fecal coliform were generally higher downstream but, again, the higher counts were not significantly different statistically from the upstream coliform count. The results for heavy metals also indicated no significant difference, indicating that the metals in the test effluent did not contribute to the groundwater contamination. Boron at both levels (by 65 and 79 percent), and fluoride at the lower well column level (by 25 percent) were found to be significantly higher (confidence level between 96 and 99 percent) downstream. Potassium showed a probable increase (90 and 95 percent confidence level) downstream at the upper well column level. Both total nitrogen (by 145 and 125 percent) and nitrates (by 145 and 136 percent) were significantly greater downstream from test well 2. Thus, the nutrients from the test effluent, excluding phosphate, tended to leach through to the groundwater. Phosphate was not found to be significantly different between the upstream and downstream wells.

Soil Analyses

The statistical results comparing the test and control site soil analyses are given in Tables 16 to 21. Seven soil samples were taken at each location from both sites at the beginning and end of the monitoring period. The H-test was the criteria used to decide which constituents were significantly different. Results for the initial soil samples are presented in Table 16 and the statistical summary is presented in Table 17. The final soil results are shown in Tables 18 and 19. The following constituents were different at the 90 percent or higher confidence level for both initial and final samples: fluoride, nitrates, phosphates,potassium,sodium, chromium, copper, manganese, nickel, and zinc.

The final test and control site samples differed at the 90 percent significance level. The only constituents that did not differ at the 90 percent level were silver, total cadmium, molybdenum, mercury and selenium. The actual values for these five metals were below the range of the detection level limits of the atomic absorption method of analysis, which accounted for the indeterminate results.

An evaluation of changes occurring between the initial and final soil samples at the test and control sites was performed to assess changes over time. The results are given on Table 20 and 21. The results indicate that the initial and final soil samples differed at the 96 to 99 percent significance level for both the test and control sites. More than 50 percent of the constituents analyzed decreased in concentration over time at both sites.

TABLE 14. STATISTICAL SUMMARY OF TEST WELL TOP SAMPLES: UPSTREAM (2) VS. DOWNSTREAM (3)

Constituent/ Form	Significance Level, Percent											
	96 - 99%			90 - 95%			Less than 90%			Questionable Results[a]		
	Mean Values[b] Wells (2)	(3)	%[c] Diff.	Mean Values Wells (2)	(3)	% Diff.	Mean Values Wells (2)	(3)	% Diff.	Mean Value Wells (2)	(3)	% Diff.
TC										58	1,180	1,900
FC										< 2	100	4,900
TDS	695	1,135	+63									
B	0.3	0.6	+100									
Cl	224	340	+52									
F							0.53	0.42	-21			
NO_3-N	4.9	12.0	+145									
TN	6.4	15.2	+138									
TOC							25.2	26.1	+4			
PO_4-P							0.6	1.7	+183			
SO_4							82	84	+2			
K				7.2	9.0	+25						
Na	158	228	+44									
Ca	35	60	+71									
Mg	44	78.5	+78									
Ba							0.21	0.24	+14			
Cd							0.01	0.01	0			
Cr							0.04	0.03	-25			
Cu							0.07	0.07	0			
Mo							0.10	0.12	+20			
Ni							0.03	0.05	+67			
Pb							0.13	0.14	8			
Zn							0.33	0.22	-33			
As							0.02	0.02	0			
Se							0.01	0.01	0			

[a] Indeterminate because values were less than detection limit.

[b] The average value in mg/kg of results from seven depths.

[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.

TABLE 15. STATISTICAL SUMMARY OF TEST WELL BOTTOM SAMPLES: UPSTREAM (2) VS. DOWNSTREAM (3)

Constituent/ Form	Significance Level, Percent									Questionable Results[a]		
	96 - 99%			90 - 95%			Less than 90%					
	Mean Values[b] Wells (2)	(3)	%[c] Diff.	Mean Values Wells (2)	(3)	% Diff.	Mean Values Wells (2)	(3)	% Diff.	Mean Value Wells (2)	(3)	% Diff.
TC										826	94	-89
FC										3	2	-50
TDS	744	1,193	+60									
B	0.34	0.61	+79									
Cl	230	357	+55									
F	0.63	0.79	+25									
NO_3-N	4.2	9.9	+136									
TN	5.3	11.9	+125									
TOC							21.4	31.1	+45			
PO_4-P							0.62	2.5	+303			
SO_4							65	78	+20			
K							6.8	11.7	+72			
Na	156	217	+39									
Ca	28.9	58.9	+104									
Mg	42.1	83.8	+99									
Ba							0.16	0.19	+19			
Cd							0.01	0.01	0			
Cr							0.02	0.03	+50			
Cu							0.06	0.07	+17			
Mo							0.11	0.10	-9			
Ni							0.03	0.05	+67			
Pb							0.20	0.19	-5			
Zn							0.19	0.26	+37			
As							0.02	0.02	0			
Se							0.01	0.01	0			

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[a] Indeterminate because values were less than detection limit.

[b] The average value in mg/kg of results from seven depths.

[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.

TABLE 16. INITIAL SOIL CHEMICAL ANALYSES (OCTOBER 1976),[a] (mg/kg unless noted)

Site	Depth (cm)	B WE[c]	Cl WE	F WE	NO_3-N WE	N[b] T[d]	PO_4 WE	P AE[e]	P Organic T	K WE	 Ex[f]	Na WE	Ca AE	 WE	 Ex
Test	1	4.7	138	6	58	1,460	15.4	1,260	265	57	3,490	138	13,600	34	2,650
	3	4.0	39	2	43	884	25.5	1,540	250	62	3,230	114	16,000	22	5,170
	10	2.8	39	8	26	694	21.5	1,277	<20	63	3,000	127	15,000	32	4,200
	30	2.3	29	5	9.9	409	18	960	35	70	3,190	136	15,800	21	3,070
	100	3.4	39	3	29	223	16	660	45	62	2,620	118	14,200	17	6,890
	200	3.9	<10	1	<1.0	92	5.0	340	95	72	3,160	114	14,600	12	3,150
	300	2.8	78	1	<1.0	42	11.5	330	40	80	3,200	96	13,000	16	1,780
Mean		3.4	53	3.7	23	543	16.1	908	105	66	3,127	120	14,600	22	3,844
Std. Dev.		0.8	42	2.6	21	509	6.6	478	106	7.8	266	14	1,101	8	1,728
Control	1	4.0	78	12	<1.0	771	<1.0	910	135	76	1,760	146	8,600	119	10,400
	3	3.6	78	10	<1.0	466	<1.0	840	85	116	1,980	188	9,900	115	11,500
	10	3.4	98	5	<1.0	384	<1.0	870	75	120	2,300	196	9,600	109	11,600
	30	3.4	78	7	<1.0	152	<1.0	880	80	130	1,840	210	9,600	92	9,760
	100	3.4	59	10	<1.0	316	<1.0	670	55	121	1,780	276	10,400	58	11,000
	200	3.9	256	4	<1.0	128	<1.0	720	35	140	2,270	281	11,800	76	12,400
	300	3.3	177	5	<1.0	104	<1.0	590	45	94	1,170	290	10,400	54	13,900
Mean		3.5	117	7.5	<1.0	331	<1.0	782	72.86	113	1,871	226	10,043	89	11,508
Std. Dev.		0.2	72	3.1	--	237	--	127	33.15	21	380	55	986	26	1,358

(continued)

TABLE 16. (continued), (mg/kg unless noted)

Site	Depth	Mg				CEC [g]	Ag		Ba	Cd		Cr		Cu		Mn	
	(cm)	T	AE	WE	Ex		T	AE	T	T	AE	T	AE	T	AE	T	AE
Test	1	14,300	2,860	33	672	27.3	<20	<1.0	690	8.0	0.8	563	0.4	299	0.4	288	78
	3	19,200	2,440	32	704	32.5	<20	<1.0	530	6.0	0.8	538	0.3	282	0.3	178	82
	10	15,300	2,820	31	472	24.8	<20	<1.0	500	7.0	0.6	541	0.4	292	0.5	183	70
	30	13,800	2,170	28	644	19.7	<20	<1.0	530	5.0	0.5	529	0.3	242	0.3	241	60
	100	15,200	2,120	21	591	11.4	<20	<1.0	470	7.0	0.4	472	0.2	248	0.3	183	60
	200	11,800	1,580	21	458	10.9	<20	<1.0	550	7.0	0.4	519	0.2	232	0.3	210	49
	300	7,000	2,090	22	520	12.7	<20	<1.0	800	5.0	0.5	446	0.2	217	0.3	178	49
Mean		13,943	2,297	26	580	19.9	<20	<1.0	550	6.1	0.57	515	0.3	258	0.35	208	64
Std. Dev.		3,667	450	5.4	98	8.6	--	--	70	1.6	0.17	41	0.11	31	0.09	41	13
Control	1	16,000	1,600	40	597	20.6	<20	<1.0	530	<5.0	0.9	598	0.4	161	0.6	473	39
	3	15,900	1,500	39	705	19.1	<20	<1.0	540	<5.0	1.2	538	0.4	155	0.5	447	33
	10	18,100	1,650	26	625	19.6	<20	<1.0	510	<5.0	1.0	544	0.3	164	0.4	401	23
	30	15,600	1,480	32	537	13.3	<20	<1.0	500	<5.0	1.0	587	0.3	155	0.4	305	30
	100	20,400	1,570	26	604	12.9	<20	<1.0	480	<5.0	1.2	617	0.3	142	1.1	491	26
	200	17,200	1,350	23	508	9.6	<20	<1.0	510	<5.0	0.7	599	0.3	141	0.4	485	20
	300	11,200	1,570	18	615	11.7	<20	<1.0	610	<5.0	0.7	551	0.3	119	0.2	475	22
Mean		16,342	1,531	29	598	15.2	<20	<1.0	525	<5.0	0.96	576	0.3	148	0.51	439	27
Std. Dev.		2,816	98	5.4	63	4.4	--	--	41	--	0.21	31	0.05	15	0.29	66	6.8

(continued)

TABLE 16. (continued), (mg/kg unless noted)

Site	Depth (cm)	Mo	Ni		Pb		Zn		As		Hg		Se		pH
		T	T	AE	T	AE	T[h]	AE	T	AE	T	AE	T	AE	
Test	1	< 20	89	1.4	78	1.5		5.4	2.4	0.2	<0.5	< 0.05	< 2.0	< 0.10	7.6
	3	< 20	112	1.7	49	1.2		5.2	2.5	0.2	<0.5	< 0.05	< 2.0	< 0.10	7.8
	10	< 20	97	1.7	53	1.9		6.3	3.2	0.2	<0.5	< 0.05	< 2.0	< 0.10	8.0
	30	< 20	91	2.1	37	1.4		2.9	4.0	0.2	<0.5	< 0.05	< 2.0	< 0.10	8.4
	100	< 20	101	2.0	34	2.1		2.4	2.8	0.1	<0.5	< 0.05	< 2.0	< 0.10	8.4
	200	< 20	83	2.6	37	2.0		1.3	3.4	0.1	<0.5	< 0.05	< 2.0	< 0.10	8.7
	300	< 20	75	1.5	39	1.2		1.5	2.9	0.1	<0.5	< 0.05	< 2.0	< 0.10	8.3
Mean		< 20	92	1.8	46	1.6		3.5	3.1	0.16	<0.5	< 0.05	< 2.0	< 0.10	8.1
Std. Dev.		--	12	0.4	15	0.3		2.0	0.5	0.05	--	--	--	--	0.3
Control	1	< 20	97	0.7	45	3.0		0.8	5.0	0.2	<0.5	< 0.05	< 2.0	< 0.10	7.6
	3	< 20	95	1.1	53	2.1		0.8	6.5	0.2	<0.5	< 0.05	< 2.0	< 0.10	8.0
	10	< 20	87	0.9	51	1.9		0.7	6.7	0.2	<0.5	< 0.05	< 2.0	< 0.10	8.0
	30	< 20	103	1.0	35	2.4		0.7	7.8	0.2	<0.5	< 0.05	< 2.0	< 0.10	8.4
	100	< 20	85	0.9	46	1.5		0.9	5.0	0.2	<0.5	< 0.05	< 2.0	< 0.10	8.4
	200	< 20	160	1.2	50	1.5		0.6	4.8	0.1	<0.5	< 0.05	< 2.0	< 0.10	8.6
	300	< 20	185	1.6	35	1.6		1.2	4.3	0.2	<0.5	< 0.05	< 2.0	< 0.10	8.4
Mean		< 20	116	1.0	45	2.0		0.8	5.7	0.19	<0.5	< 0.05	< 2.0	< 0.10	8.2
Std. Dev.		--	39	0.2	7	0.5		0.1	1.2	0.04	--	--	--	--	0.3

[a] Averages of two sub-composited samples.
[b] Total nitrogen = nitrates plus kjeldahl nitrogen.
[c] WE = water extractible.
[d] T = total digestible.
[e] AE = acid extractible.
[f] Ex = exchangeable.
[g] Reported as meq/100 gm
[h] Bad sample

TABLE 17. STATISTICAL SUMMARY OF INITIAL SOIL CHEMICAL ANALYSES (OCTOBER 1976)

Constituent/ Form		Significance Level, Percent: 96 - 99% Mean Values[b] Control	Test	%[c] Diff.	90 - 95% Mean Values Control	Test	% Diff.	Less than 90% Mean Values Control	Test	% Diff.	Indeterminable Results[a] Mean Value Control	Test	% Diff.
B	WE[d]							3.6	3.4	-4			
Cl	WE				118	53	-55						
F	WE	7.6	3.7	-51									
NO_3-N	WE	<1.0	23.8	+2,386									
N	T[e]							332	543	+64			
PO_4-P	WE	<1.0	16	+1,610									
P	AE[f]							783	909	+16			
P org	T							73	106	+45			
K	WE	114	67	-42									
	EX[g]	1,870	3,130	+67									
Na	WE	227	120	-47									
	AE	10,000	14,600	+46									
Ca	WE	89	22	-75									
	EX	11,500	3,840	-67									
Mg	T							16,300	13,900	-15			
	AE	1,530	2,300	+50									
	WE							29	27	-7			
	EX							599	580	-3			
CEC[h]								15.3	19.9	+30			
Ag	T										< 20	< 20	Indet.
	AE										< 1.0	< 1.0	Indet.
Ba	T							525	550	+5			
Cd	T	<5.0	6.1	≥+22									
	AE	1.0	0.6	-40									
Cr	T	576	515	-11									
	AE							0.3	0.3	0			
Cu	T	148	259	+75									

(continued)

TABLE 17 (continued)

Constituent/ Form		Significance Level, Percent 96 - 99% Mean Control	Values[b] Test	%[c] Diff.	90 - 95% Mean Control	Values Test	% Diff.	Less than 90% Mean Control	Values Test	% Diff.	Indeterminable Results[a] Mean Control	Value Test	% Diff.
	AE							0.5	0.4	-20			
Mn	T	440	209	-53									
	AE	28	64	+129									
Mo	T										20	20	Indet.
Ni	T							116	93	-20			
	AE	1.1	1.9	+75									
Pb	T							45	47	+4			
	AE							2.0	1.6	-20			
Zn	T												
	AE	0.8	3.6	+334									
As	T	5.7	3.1	-46									
	AE							0.2	0.2	0			
Hg	T										< 0.5	< 0.5	Indet.
	AE										< 0.05	< 0.05	Indet.
Se	T										< 2.0	< 2.0	Indet.
	AE										< 0.1	< 0.1	Indet.
pH								8.2	8.2	0			

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[a] Indeterminate because values were less than detection limit.
[b] The average value, in mg/kg, of results from seven depths.
[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.
[d] WE=water extractible.
[e] T = total digestible.
[f] AE = acid extractible.
[g] EX = exchangeable.
[h] Value reported as meq/100 gm.

TABLE 18. FINAL SOIL CHEMICAL ANALYSES (DECEMBER 1977)[a], (mg/kg unless noted)

Site	Depth (cm)	B	Cl	F	NO_3-N	N[b]	PO_4-P	P	P Organic	K		Na		Ca	
		WE	WE	WE	WE	T[d]	WE	AE	T	WE	Ex[f]	WE	AE	WE	Ex
Test	1	2.6	307	2	54	233	25	110	200	123	1,210	423	15,500	7.4	2,240
	3	2.2	193	5	36	377	13	90	190	162	1,110	545	15,200	0.5	1,900
	10	1.5	80	3	22	172	21	41	160	103	1,180	362	17,300	6.8	1,960
	30	1.0	100	1	26	79	14	26	105	74	1,050	299	17,600	5.7	1,960
	100	0.8	87	2	17	101	14	31	60	71	989	266	16,300	6.5	1,620
	200	0.7	37	1	6.7	17	12	77	125	65	838	185	13,800	11.1	1,620
	300	0.9	10	1	4.4	14	6.0	125	140	45	821	161	14,100	6.8	1,460
Mean		1.39	116.29	2.14	23.73	141.86	15.00	56.71	140	91.86	1,028.29	320.14	15,685	6.40	1,822.9
Std. Dev.		0.75	101.88	1.46	17.24	130.43	6.22	35.16	48.90	40.18	154.87	135.31	1,471.3	3.13	268.19
Control	1	1.4	424	1	187	818	1.2	34	120	92	1,480	511	14,300	--	2,680
	3	1.3	174	5	37	573	6.8	23	115	212	1,150	366	13,900	11.1	2,150
	10	0.7	125	5	17	626	3.9	24	140	105	1,150	331	13,900	8.5	3,740
	30	0.7	100	2	9.5	252	3.3	26	55	93	1,040	306	16,900	7.5	2,330
	100	0.6	100	5	6.3	243	3.9	16	70	170	1,190	443	17,000	5.2	2,080
	200	2.7	87	13	36	131	15	6.5	<20	291	440	836	15,900	2.9	1,530
	300	2.0	325	10	29	120	11	15	30	250	379	879	15,100	3.1	1,560
Mean		1.34	190.71	5.86	42.35	394.71	6.44	20.64	77.14	173.29	989.86	524.51	15,286	6.38	2,295.71
Std. Dev.		0.78	131.83	4.26	59.56	274.73	4.92	8.94	49.15	80.59	414.25	237.99	1,339	3.23	756.11

(continued)

TABLE 18 (continued),(mg/kg unless noted)

Site	Depth (cm)	Mg T	Mg AE	Mg WE	Mg Ex	CEC^g	Ag T	Ag AE	Ba T	Cd T	Cd AE	Cr T	Cr AE	Cu T	Cu AE	Mn T	Mn AE
Test	1	4,950	6,250	14.0	405	11.8	<20	<1.0	529	<5	0.3	239	0.2	33	0.7	626	56
	3	6,800	5,500	17.1	353	11.9	< 20	<1.0	438	<5	0.2	206	0.2	31	0.6	598	48
	10	7,500	4,700	10.3	435	16.8	< 20	<1.0	448	<5	0.2	234	0.2	34	0.6	600	28
	30	420	5,000	8.8	393	14.3	< 20	<1.0	467	<5	0.2	233	0.3	35	0.5	623	27
	100	7,000	4,950	7.9	270	10.3	< 20	<1.0	413	<5	0.3	213	0.2	23	0.5	608	32
	200	5,730	3,250	10.7	150	7.1	< 20	<1.0	391	<5	0.2	267	0.2	19	1.7	731	39
	300	6,700	4,830	7.6	169	7.2	< 20	<1.0	411	<5	0.3	297	0.2	42	0.7	736	43
Mean		6,585.71	4,925.7	10.91	310.71	11.34	<20	<1.0	442.43	<5.0	0.24	241.29	0.21	31.00	0.76	646	39.00
Std. Dev.		928.29	909.01	3.48	115.81	3.54	--	--	45.91	--	0.05	31.46	0.04	7.72	0.42	60.72	10.80
Control	1	9,500	3,770	55.3	890	29.0	<20	< 1.0	800	<5	0.3	372	0.2	51	0.7	864	24
	3	10,500	3,630	16.1	757	25.3	< 20	< 1.0	753	<5	0.3	278	0.2	48	0.6	827	17
	10	17,100	4,770	12.7	962	24.3	< 20	< 1.0	892	<5	0.2	467	0.2	61	0.6	1,070	21
	30	11,100	2,130	9.9	864	19.9	< 20	< 1.0	1,057	<5	0.3	401	0.4	56	0.5	1,040	14
	100	17,000	3,070	11.8	720	24.0	< 20	< 1.0	1,023	<5	0.3	407	0.3	63	0.6	1,120	13
	200	10,500	3,050	30.3	950	14.0	< 20	< 1.0	586	<5	0.3	402	0.2	43	0.5	950	21
	300	9,630	2,470	17.4	553	13.9	< 20	< 1.0	709	<5	0.2	484	0.2	48	0.5	1,180	26
Mean		12,190	3,270.00	21.93	813.71	21.49	<20	< 1.0	831.43	<5.0	0.27	401.57	0.24	52.86	0.57	007.29	19.43
Std. Dev.		3,364.87	881.06	16.18	146.56	5.79	--	--	170.10	--	0.05	67.39	0.08	7.38	0.08	131.56	4.93

(continued)

TABLE 18 (continued), (mg/kg unless noted)

	Depth (cm)	Mo	Ni		Pb		Zn		As		Hg		Se	
		T	T	AE	T	AE	T	AE	T	AE	T	AE	T	AE
Test	1	< 20	55	1.6	137	7.9	6.1	1.5	2.7	0.2	<0.5	< 0.05	2.0	<0.1
	3	< 20	54	1.2	132	8.2	5.0	1.2	2.5	0.2	<0.5	< 0.05	2.9	<0.1
	10	< 20	52	1.2	167	8.1	5.4	0.7	2.4	0.2	<0.5	< 0.05	5.0	<0.1
	30	< 20	59	1.1	118	8.7	6.5	0.7	4.9	0.2	<0.5	< 0.05	<2.0	<0.1
	100	< 20	56	1.4	142	7.8	4.4	0.7	< 2.0	0.1	<0.5	< 0.05	14	<0.1
	200	< 20	61	1.5	145	8.7	4.9	2.8	2.1	0.3	<0.5	< 0.05	13	<0.1
	300	< 20	57	2.0	117	8.5	5.5	2.0	< 2.0	0.2	<0.5	< 0.05	5.2	<0.1
Mean		< 20	56.29	1.43	136.86	8.27	5.40	1.37	2.51	0.20	< 0.5	< 0.05	6.01	<0.1
Std. Dev.		--	3.04	0.31	17.20	0.37	0.72	0.80	1.19	0.06	--	--	5.39	--
Control	1	< 20	94	1.5	174	9.7	7.3	0.4	3.4	0.4	<0.5	< 0.05	22	<0.1
	3	< 20	91	1.3	170	9.5	8.2	0.7	3.3	0.3	<0.5	< 0.05	8.8	<0.1
	10	< 20	134	1.5	235	9.9	9.3	0.6	5.2	0.4	<0.5	< 0.05	17	<0.1
	30	< 20	124	1.3	196	9.7	8.7	0.6	5.6	0.4	<0.5	< 0.05	17	<0.1
	100	< 20	125	1.2	259	8.9	8.9	0.5	< 2.0	0.2	<0.5	< 0.05	8.9	<0.1
	200	< 20	105	1.3	165	8.7	8.3	0.6	4.4	0.2	<0.5	< 0.05	10	<0.1
	300	< 20	129	1.5	218	8.7	9.1	0.5	3.2	0.2	<0.5	< 0.05	12	<0.1
Mean		< 20	114.57	1.37	202.43	9.30	8.54	0.56	3.73	0.30	<0.5	< 0.05	13.24	<0.1
Std. Dev.		--	17.58	0.13	36.07	0.52	0.68	0.10	1.53	0.10	--	--	4.87	--

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[a] Averages of two sub-composited samples.
[b] Total nitrogen = nitrates plus kjeldahl nitrogen.
[c] WE = water extractible.
[d] T = total digestible.
[e] AE = acid extractible.
[f] Ex = exchangeable.
[g] Reported at meq/100 gm.

TABLE 19. STATISTICAL SUMMARY OF FINAL SOIL CHEMICAL ANALYSES (DECEMBER 1977)

Constituent/	Form	Significance Level, Percent 96 - 99% Mean Control	Values[b] Test	%[c] Diff.	90 - 95% Mean Control	Values Test	% Diff.	Less than 90% Mean Control	Values Test	% Diff.	Indeterminable Results[a] Mean Control	Value Test	% Diff.
B	WE[d]							1.3	1.4	+4			
Cl	WE							191	116	-39			
F	WE	6	2	-67									
NO_3	WE							42	24	-44			
N	T[e]	395	142	-64									
PO_4-P	WE	6.4	15	+134									
P	AE[f]	21	57	-175									
P org	T	77	170	+120									
K	WE	173	92	-47									
	EX[g]							940	1,030	+4			
Na	WE				525	320	-39						
	AE							15,300	15,700	+3			
Ca	WE							6.4	6.4	0			
	EX							2,300	1,820	-21			
Mg	T	12,200	6,600	-46									
	AE	3,300	4,900	+51									
	WE				21.9	10.9	-50						
	EX	813.7	310.7	-62									
CEC[h]		21.5	11.3	-47									
Ag	T										<20	<20	Indet.[b]
	AE										< 1.0	< 1.0	Indet.
Ba	T	831	442	-47									
Cd	T										< 5.0	< 5.0	Indet.
	AE												
Cr	T	402	241	-40									
	AE							0.3	0.2	-33			

(continued)

TABLE 19 (continued)

Constituent/ Form		Significance Level, Percent											
		96 - 99%			90 - 95%			Less than 90%			Indeterminable Results		
		Mean Control	Values[b] Test	%[c] Diff.	Mean Control	Values Test	% Diff.	Mean Control	Values Test	% Diff.	Mean Control	Value Test	% Diff.
Cu	T	53	31	-42				0.2	0.2	-0			
	AE												
Mn	T	1,010	650	-36				0.6	0.8	+33			
	AE	19	39	+105									
Mo	T										<20	< 20	Indet.
Ni	T	115	56	-51									
	AE	1.4	1.4	+4									
Pb	T	202	137	-32									
	AE	9.3	8.3	-11									
Zn	T	8.5	5.4	-36									
	AE	0.6	1.4	+133									
As	T				3.7	2.5	-33						
	AE	0.3	0.2	-33									
Hg	T										0.5	0.5	Indet.
	AE										0.05	0.05	Indet.
Se	T	13	6.0	-54									
	AE										0.1	0.1	Indet.

[a] Indeterminable because values were less than detection limit.
[b] The average value, in mg/kg, of results from seven depths.
[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.
[d] WE=water extractible.
[e] T = total digestible.
[f] AE = acid extractible.
[g] EX = exchangeable.
[h] Value reported as mg/100 gm.

TABLE 20 . STATISTICAL SUMMARY OF INITIAL AND FINAL TEST SITE SOIL CHEMICAL ANALYSES

Constituent/	Form	Significance Level, Percent											
		96 - 99%			90 - 95%			Less than 90%			Indeterminable Results[a]		
		Mean Values[b] Initial	Final	%[c] Diff.	Mean Values Initial	Final	% Diff.	Mean Values Initial	Final	% Diff.	Mean Value Initial	Final	% Diff.
B	WE[d]	3.4	1.4	-59									
Cl	WE							53	116	+119			
F	WE							3.7	2.1	-42			
NO_3-N	WE							24	24	0			
N	T[e]	543	142	-74									
PO_4-P	WE	16	15	-7									
P	AE[f]	909	57	-94									
P org	T	106	170	+60									
K	WE	67	92	+38									
	EX[g]	3,130	1,030	-67									
Na	WE	120	320	+167									
	AE							14,600	15,700	+8			
Ca	WE	22	6.4	-71									
	EX	3,840	1,820	-53									
Mg	T	13,900	6,590	-53									
	AE	2,300	4,930	-114									
	WE	27	11	-59									
	EX	580	311	-46									
CEC[h]		20	11	-45									
Ag	T										< 20	< 20	Indet.
	AE										< 1.0	< 1.0	Indet.
Ba	T	550	442	-20									
Cd	T	6.1	< 5.0	-≥17									
	AE	0.6	0.2	-58									
Cr	T	515	241	-53									
	AE	0.3	0.2	-32									

(continued)

TABLE 20 .(continued)

Constituent/ Form		Significance Level, Percent 96 - 99% Mean Initial	Values[b] Final	% [c] Diff.	90 - 95% Mean Initial	Values Final	% Diff.	Less than 90% Mean Initial	Values Final	% Diff.	Indeterminable Results[a] Mean Initial	Value Final	% Diff.
Cu	T	259	31	-88									
	AE	0.4	0.8	+117									
Mn	T	209	646	+209									
	AE	64	39	-39									
Mo	T										<20	< 20	Indet.
Ni	T	93	56	-39									
	AE	19	1.4	-26									
Pb	T	47	137	+191									
	AE	1.6	8.3	+414									
Zn	T	80.3	5.4	-93									
	AE	3.6	1.4	-62									
As	T							3.1	2.5	-19			
	AE							0.2	0.2	0	< 0.5	< 0.5	Indet.
											< 0.5	< 0.5	Indet.
Se	T	< 2	6.0	+≥200							< 0.1	< 0.1	Indet.

[a] Indeterminable because values were less than detection limit.

[b] The average value, in mg/kg, of results from seven depths.

[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.

[d] WE: water extracible.

[e] T = total digestible.

[f] AE = acid extractible.

[g] EX = exchangeable.

[h] Value reported as mg/100 gm.

TABLE 21. STATISTICAL SUMMARY OF INITIAL AND FINAL CONTROL SITE SOIL CHEMICAL ANALYSES

Constituent/ Form		Significance Level, Percent											
		96 - 99%			90 - 95%			Less than 90%			Indeterminable Results[a]		
		Mean Values[b]		%[c]	Mean Values		%	Mean Values		%	Mean Value		%
		Initial	Final	Diff.	Initial	Final	Diff.	Initial	Final	Diff.	Initial	Final	Diff.
B	WE[d]	3.6	1.3	-62									
Cl	WE							117.7	190.7	+62			
F	WE							7.57	5.86	-23			
NO_3-N	WE	<1.0	42	>14,000									
N	T[e]							332	395	+19			
PO_4-P	WE	<1.0	6.4	+644									
P	AE[f]	783	21	-97									
P org	T							73	77	+5			
K	WE				114	173	+52						
	EX[g]	1,870	999	-45									
Na	WE	227	525	+131									
	AE	10,000	15,300	+52									
Ca	WE	89	640	-93									
	EX	11,500	2,300	-80									
Mg	T	16,300	12,200	-25									
	AE	1,530	3,270	+114									
	WE							29	22	-25			
	EX	599	814	+36									
CEC[h]		15.3	215	+41									
Ag	T										<20	<20	Indet.
	AE										< 1.0	< 1.0	Indet.
Ba	T	525	831	+58									
Cd	T										5.0	5.0	Indet.
	AE	1	0.3	-70									
Cr	T	576	402	-30									
	AE	0.3	0.2	-33									

(continued)

TABLE 21. (continued)

Constituent/ Form		Significance Level, Percent 96 - 99% Mean Values[b] Initial	Final	%[c] Diff.	90 - 95% Mean Values Initial	Final	% Diff.	Less than 90% Mean Values Initial	Final	% Diff.	Indeterminable Results[a] Mean Value Initial	Final	% Diff.
Cu	T	148	53	-64									
	AE							0.5	0.6	+20			
Mn	T	440	1,010,	+129									
	AE	28	19	-32							< 20	< 20	Indet.
Mo	T							116	115	-1			
Ni	T												
	AE	1.1	1.4	+27									
Pb	T	45	202	+349									
	AE	2.0	9.3	+365									
Zn	T	97	8.5	-91									
	AE	0.8	0.6	-32									
As	T	5.7	3.7	-35									
	AE	0.2	0.3	+50							≤ 0.5	< 0.5	Indet.
Hg	T										< 0.05	< 0.05	Indet.
	AE												
Se	T	< 2.0	13	>+550							< 0.1	< 0.1	Indet.
	AE												

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[a] Indeterminable because values were less than detection limit.
[b] The average value, in mg/kg, of results from seven depths.
[c] The percent the test result increased (designated by a "+" sign) or decreased (designated by a "-" sign) over the control.
[d] WE: water extractible.
[e] T = total digestible.
[f] AE = acid extractible.
[g] EX = exchangeable.
[h] Value reported as mg/100 gm.

The biological organism analysis for the initial and final soil samples is presented in Tables 22 and 23. The fecal coliform count in the test and control soils, and from the initial to the final soil samplings, was less than the detectable limits of the tests at all depths. Protozoa, nematodes, and total coliform populations generally decreased by at least a factor of 10 from the surface to the 300-cm depth. No nematodes or total coliform were detected below the 100-cm depth in the initial samples at both sites. The biological populations were compared statistically between the test and control sites, and the initial and final samplings at each site as shown on Table 24. The bacterial population found in the test site soil did not differ significantly between the initial and the final samplings at each site. Protozoa and nematodes, however, significantly decreased at both sites during the study. The protozoa population was reduced by 52 percent in the control soil and by 95 percent in the test soil. Nematodes decreased from more than 30 to less than one at both sites.

WATER QUALITY COMPARISON

The irrigation waters, leachate from the lysimeter, and the groundwater from the wells were compared with the EPA interim drinking water regulations and the California water quality criteria for beneficial uses. The comparative results are listed in Tables 25 to 27.

The comparative study between the irrigation waters and the water quality criteria gave the following results (Table 25). The test effluent exceeded the permissible limits more often than the control site for total coliform (95 percent to 50 percent); fecal coliform (80 percent to 29 percent); total dissolved solids (100 percent to 89 percent); chloride (88 percent to 62 percent); fluoride (71 percent to 19 percent), cadmium (39 percent to 36 percent); and lead (65 percent to 44 percent). Only the test arsenic criteria was exceeded less often than the control site constituent, zero percent compared to 10 percent. Boron, nitrate-nitrogen, sulfate, barium, copper, nickel, zinc and selenium criteria were not exceeded at either site.

The following constituents did not exceed the water quality criteria for any samples on the test and control sites: boron, except the leachate from the 100-cm test lysimeter; barium; copper, except the leachate from the 100-cm control lysimeter, nickel, zinc, and selenium (Table 26). The total dissolved solids were exceeded for all samples nearly 100 percent of the time.

The following results were found when the leachate values were compared with the water quality criteria. Chlorides and nitrates exceeded the permissible limits by 100 percent for both the test and the control. Sulfate and total coliform criteria were not exceeded. No fecal coliform exceeded the limit at the 50-cm level, but the limit was exceeded at the 100-cm level in 11 percent of the test site and 50 percent of the control site samples. Cadmium and chromium criteria were not exceeded at the 50-cm depth, but were exceeded at the 100-cm depth (50 percent for cadmium in the test leachate, and 67 and 50 percent of the time for chromium in the test and control, TABLE 22 . INITIAL SOIL BIOLOGICAL ORGANISM ANALYSES (OCTOBER 1976)

Site	Depth (cm)	Protozoa (Pop/10 gm)[a]	Nematodes (Population/10 gms)[a]	Total Coliform (MPN/gm)[a]	Fecal Coliform (MPN/gm)[a]
Test	1	1×10^4	20	2.5×10^5	< 20
	3	1×10^4	65	2.5×10^6	< 20
	10	<20	100	2.0×10^5	< 20
	30	1×10^4	63	2.0×10^4	< 20
	100	1×10^4	30	6.0×10^3	< 20
	300	1×10^2	0	< 20	< 20
Mean		7.2×10^3	46	5.0×10^5	< 20
Std. Dev.		4.9×10^3	36	9.9×10^5	0
Control	1	1×10^4	15	6.0×10^4	< 20
	3	1×10^4	20	2.5×10^5	< 20
	10	1×10^4	90	6.0×10^4	< 20
	30	1×10^4	70	1.3×10^4	< 20
	100	1×10^4	15	2.5×10^2	< 20
	200	1×10^3	0	< 20	< 20
	300	1×10^2	0	<20	< 20
Mean		7.3×10^3	30	5.5×10^4	< 20
Std. Dev.		4.6×10^3	36	9.0×10^4	0

[a] Dry weight soil.

TABLE 23. FINAL SOIL BIOLOGICAL ORGANISM ANALYSIS (DECEMBER 1977)

Site	Depth (cm)	Protozoa (Pop/10 gm)[a]	Nematodes (Population/10 gms)[a]	Total Coliform (MPN/gm)[a]	Fecal Coliform (MPN/gm)[a]
Test	1	1,800	5	2.7×10^4	<20
	3	210	2	1.0×10^5	<20
	10	210	1	1.6×10^3	<20
	30	210	0	8.5×10^3	<20
	100	< 20	0	2.8×10^3	<20
	200	< 20	0	2.1×10^3	<20
	300	<20	0	6.7×10^2	<20
Mean		360	1	2.0×10^4	<20
Std. Dev.		640	2	3.6×10^4	0
Control	1	<20	0	3.5×10^3	<20
	3	1,400	0	1.9×10^4	<20
	10	930	0	7.7×10^4	<20
	30	< 20	0	5.9×10^4	<20
	100	<20	0	2.7×10^3	<20
	200	<20	0	3.4×10^2	<20
	300	<20	0	1.3×10^3	<20
Mean		350	0	2.3×10^4	<20
Std. Dev.		570	0	3.2×10^4	0

[a] Dry weight soil.

TABLE 24. STATISTICAL SUMMARY OF BIOLOGICAL ORGANISM ANALYSIS OF SOIL SAMPLES

Confidence Level Comparison Relationship	Constituent	96-99% Mean Values Control	96-99% Mean Values Test	% Differ.	Less than 90% Mean Values Control	Less than 90% Mean Values Test	Less than 90% Percent Difference
Initial Control/ Test	Protozoa				7.3×10^3	7.2×10^3	-1
	Nematodes				30	46	53
	Total coliform				5.5×10^4	5.0×10^5	800
	Fecal coliform				<20	<20	--
Final Control/ Test	Protozoa				3.5×10^2	3.6×10^2	3
	Nematodes				0	1	--
	Total coliform				2.3×10^4	2.0×10^4	-13
	Fecal coliform				<20	<20	--
Control Initial/ Final	Initial	Initial	Final		Initial	Final	
	Protozoa	7.3×10^3	3.5×10^2	-52			
	Nematodes	30	0	-100			
	Total coliform				5.5×10^4	2.3×10^4	-58
	Fecal coliform				<20	<20	--
Test Initial/ Final	Protozoa	7.2×10^3	3.6×10^2	-95			
	Nematodes	46	1	-98			
	Total coliform				5.0×10^5	2.0×10^4	-96
	Fecal coliform				<20	<20	--

TABLE 25. COMPARISON OF THE IRRIGATION WATER ANALYSES WITH THE WATER QUALITY CRITERIA FOR MUNICIPAL AND IRRIGATION WATER SUPPLIES.

Site	Source	Percent of Time Constituent Exceeded Water Quality Criteria							
		TC (100 MPN)[a]	FC (20 MPN)	TDS (500 mg/l)	B (1.0 mg/l)	Cl (250 mg/l)	F (1.0 mg/l)[b]	NO_3-N (10 mg/l)[c]	SO_4 (250 mg/l)
Test	Effluent	95	80	100	0	88	71	0	0
Control	Irrigation	50	29	89	0	62	19	0	0

Site	Source	Percent of Time Constituent Exceeded Water Quality Criteria								
		Ba (1.0 mg/l)[c]	Cd (0.01 mg/l)	Cr (0.05 mg/l)[c]	Cu (1.0 mg/l)	Ni (0.2 mg/l)[b]	Pb (0.05 mg/l)[c]	Zn (5 mg/l)	As (0.05 mg/l)[c]	Se (0.01 mg/l)[c]
Test	Effluent	0	39	24	0	0	65	0	0	0
Control	Irrigation	0	36	14	0	0	44	0	10	0

[a] Permissible criteria for each constituent is given in parenthesis: water quality criteria for municipal water supplies, unless otherwise noted.

[b] Recommended maximum concentration in irrigation waters.

[c] Maximum contaminant level for the EPA interim primary drinking water regulations, 1977.

TABLE 26. COMPARISON OF THE LEACHATE ANALYSES WITH THE WATER QUALITY CRITERIA FOR MUNICIPAL AND IRRIGATION WATER SUPPLIES

Site	Lysimeter Depth (cm)	Percent of Time Constituent Exceeded Water Quality Criteria							
		TC (100 MPN)[a]	FC (20 MPN)	TDS (500 mg/l)	B (1 .0 mg/l)	Cl (250 mg/l)	F (1.0 mg/l)[b]	NO_3-N[c] (10 mg/l)	SO_4 (250 mg/l)
Test	50	0	0	100	0	100	0	100	0
	100	0	11	100	25	100	20	100	0
Control	50	0	0	100	0	100		100	0
	100	0	50	100	0	100	100	100	0

Site	Lysimeter Depth (cm)	Percent of Time Constituent Exceeded Water Quality Criteria								
		Ba (1 .0 mg/l)[c]	Cd (0.01 mg/l)	Cr (0.05 mg/l)[c]	Cu (1 .0 mg/l)	Ni (0.2 mg/l)[b]	Pb (0.05 mg/l)[c]	Zn (5 mg/l)	As (0.05 mg/l)[c]	Se (0.01 mg/l)[c]
Test	50	0	0	0	0	0	50	0	0	0
	100	0	50	67	0	0	60	0	0	0
Control	50		0	0		0	100	0	0	0
	100	0	0	50	2	0	100	0	0	0

[a] Permissible criteria for each constituent is given in parenthesis: water quality criteria for municipal water supplies;unless otherwise noted. Source: 3

[b] Recommended maximum concentration in irrigation waters. Source: 4

[c] Maximum contaminant level for the EPA interim primary drinking water regulations,1977. Source: 5

TABLE 27. COMPARISON OF THE GROUNDWATER ANALYSES WITH THE WATER QUALITY CRITERIA FOR MUNICIPAL AND IRRIGATION WATER SUPPLIES

Site	Well		Percent of Time Constituent Exceeded Water Quality Criteria							
	Location	Depth	TC (100 MPN)[a]	FC (20 MPN)	TDS (500 mg/l)	B (1.0 mg/l)	Cl (250 mg/l)	F (1.0 mg/l)[b]	NO_3-N (10 mg/l)[c]	SO_4 (250 mg/l)
Test	Upstream #1	Top	27	0	100	0	33	0	12	0
		Bottom	23	0	100	0	29	0	0	0
	Upstream #2	Top	23	0	91	0	12	17	0	0
		Bottom	33	0	100	0	17	14	17	0
	Downstream	Top	29	7	100	0	89	0	40	0
		Bottom	42	0	100	0	100	14	60	0
Control	Upstream	Top	14	0	100	0	90	0	0	0
		Bottom	23	8	100	0	100	0	17	0
	Midstream	Top	20	0	100	0	100	0	17	0
		Bottom	17	8	100	0	100	0	60	0

Site	Well		Percent of Time Constituent Exceeded Water Quality Criteria								
	Location	Depth	Ba (1.0 mg/l)[a]	Cd (0.01 mg/l)	Cr (0.05 mg/l)[c]	Cu (1.0 mg/l)	Ni (0.2 mg/l)[b]	Pb (0.05 mg/l)[c]	Zn (5 mg/l)	As (0.05 mg/l)[c]	Se (0.01 mg/l)[c]
Test	Upstream	Top	0	43	17	0	0	50	0	0	0
		Bottom	0	50	17	0	0	88	0	20	0
	Midstream	Top	0	33	20	0	0	71	0	25	0
		Bottom	0	40	20	0	0	75	0	0	0
	Downstream	Top	0	43	17	0	0	75	0	0	0
		Bottom	0	50	17	0	0	57	0	0	0
Control	Upstream	Top	0	43	33	0	0	89	0	0	0
		Bottom	0	50	33	0	0	43	0	0	0
	Midstream	Top	0	43	17	0	0	78	0	0	0
		Bottom	0	33	17	0	0	50	0	0	0

(continued)

TABLE 27 (continued)

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[a] Permissible criteria for each constituent is given in parenthesis: water quality criteria for municipal water supplies, unless otherwise noted (3).

[b] Recommended maximum concentration in irrigation waters (4).

[c] Maximum contaminant level for the EPA interim primary drinking water regulations, 1977 (5).

respectively). Lead was exceeded 100 percent of the time for the control leachate, but averaged 55 percent in the test leachate.

The comparison of the groundwater values with the permissible limits resulted in the following findings (Table 27). The sulfate criteria was not exceeded. Fecal coliform was exceeded at the upper caisson of the downstream well on the test site by 7 percent, and the lower levels of the on-site #1 and #2 wells on the control site (downstream groundwater) by 8 percent. Fluoride was exceeded by 17 percent at the upper level upstream #2 well on the test site and by 14 percent at both upstream #2 and downstream wells on the test site. Arsenic was exceeded at the lower level of the upstream #1 well and the upper level of the upstream #2 well located on the test site by 20 and 25 percent, respectively. Total coliform criteria were generally exceeded by 20 to 30 percent, and cadmium criteria were exceeded from 33 to 50 percent of the time for both the test and control site groundwater. No general trend from upstream to downstream was observed. Chromium levels were exceeded by some 17 to 33 percent of the time for both sites. Chloride levels in the control groundwater were exceeded nearly 100 percent of the time. The percent that the chloride exceeded the criteria in the test groundwater varied from about 30 percent in the upstream #1 well to about 15 percent in the upstream #2 well, and approximately 95 percent in the downstream well.

AGRICULTURE BALANCES

The agricultural history of the Mesa test and control sites are given on Tables 28 and 29, respectively. Fertilizer was used on the control site but was not needed on the test site. The crop yield per hectare was similar for identical crops on both the test and control sites.

Crop Tissue Analysis

The results of crop tissue analysis are presented in Table 30. In general, the tissue samples showed that all the analyzed elements were within the expected range for crops grown with normal agricultural practices, i.e., without reclaimed effluent.

A direct comparison between the concentration of analyzed elements in the plant tissues of the sorghum, barley, and corn leaves grown on the test site, to the sudan grass and the cotton leaves and petioles grown on the control site was not possible. These crops belong to different genera, therefore, their ability to absorb and accumulate particular elements was expected to be physiologically different.

TABLE 28. TEST SITE AGRICULTURAL HISTORY

Year	Quarter	Crop	Yield (kg/ha)
1977	Summer	Corn - Barley	28–34 23
1976	Winter	Barley	23
	S	Sorghum	13.6–17
1975	W	Corn - Barley	
	S	Sorghum	
1974	W	Wheat	2.8
	S	Sorghum	
1973	W	Wheat	2.8
	S	Sorghum	
1972	W	Wheat	
	S	Bermuda Grass	--
1969–1971	W	Bermuda Grass	--

[a] Data from interview with farmer.
[b] Dry weight.

TABLE 29. CONTROL SITE AGRICULTURAL HISTORY

Year	Quarter	Crop	Yield (kg/ha)[a]	Fertilizer
1977	Summer	Cotton		1.136
1976	Year round	Sudan grass	85[b]	Ammonia
1975	Winter	Wheat	2.8	Ammonia
	Summer	Sudan grass		Ammonia
1974	Winter	Alfalfa	9	Amophos 13-39, Phosphate
	Summer	Alfalfa		Amophos 13-39, Phosphate
1973	Winter	Sorghum	1.7	Ammonia
	Summer	Sudan grass		Ammonia
1972	Winter	Sugar beet seed	2.3	Ammonia
	Summer	Wheat		Ammonia
1971	Winter	Sorghum		Ammonia
	Summer	Wheat		Ammonia
1970	Winter	Sorghum		Ammonia, Phosphate, Nitrate
	Summer	Wheat		Nitrate, Phosphate, Cow Manure
1969	Year round	Alfalfa		Nitrate, Phosphate, Cow Manure
1968	Year round	Alfalfa		Nitrate, Phosphate, Cow Manure

(continued)

TABLE 29. (continued)

Year	Quarter	Crop	Yield[a] (kg/ha)	Fertilizer
1967	Winter	Cotton		Nitrate, Phosphate, Cow Manure
	Summer	Sorghum		Nitrate, Phosphate, Cow Manure
1966	Winter	Barley		Nitrate, Phosphate, Cow Manure
	Summer	Cotton		Nitrate, Phosphate, Cow Manure

[a] Dry weight, based on interview.

[b] Wet weight.

TABLE 30. CROP TISSUE ANALYSES

Site	Date Harvested	Type	MPN/g Total Coliform	MPN/g Fecal Coliform	B	Cl	NO_3-N	PO_4-P	S-SO_4	K	Na	Ca	Mg
					Constituent (mg/kg)								
Test	Nov 1976	Sorghum Leaves	136,000	14,000	21	216	42	3,000	86	22,100	815	5,900	2,428
		Stalk	62,000	2,200	< 1.0	108	18	3,700	51	11,000	2,480	1,800	2,030
	May 1977	Barley Leaves	--	--						17,600	1,700	5,000	4,840
		Seeds	--	--						6,170	150	100	2,170
	July 1977	Corn Leaves	50	< 2	<1.0			43	25	21,400	23	5,900	2,770
Control	Nov 1976	Sudan Grass Blades	< 2	< 2	104	102	75	4,690	160	20,500	11,000	2,200	2,060
	Oct 1977	Cotton Leaves and Petioles	26,000	6,700				11		22,100	4,700	5,000	19,000

Site	Date Harvested	Type	Ba	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Zn	As	Se
			Constituent (mg/kg)											
Test	Nov 1976	Sorghum Leaves	< 1.0	1.0	< 1.0	9.8	21	88	<10	a	<1.0	18	< 0.2	< 0.2
		Stalk	< 1.0	< 1.0	< 1.0	13.0	36	30	<10	a	<1.0	55	< 0.2	< 0.2
	May 1977	Barley Leaves	39	2.0		8.0	565	41	<10		14.0	23		
		Seeds	4.9	< 1.0		4.5	61	28	<10		1.0	38		
	July 1977	Corn Leaves	63	1.0	< 1.0	18.0	276	31	<10	a	20.0	28		
Control	Nov 1976	Sudan Grass Blades	10	1.0		21.0	655	131	<10	a	0.50	45	< 0.2	
	Oct 1977	Cotton Leaves and Petioles	106	4.7	1.7	21.0	1,350	89	33	9.3	100.0	80		

[a] Nickel crucibles were initially used to digest the crop samples, therefore nickel was not determined.

Most of the crop tissue analyses were within the expected range of healthy crop tissue, as listed in Table 31. The only exceptions in the test-grown crops were the boron, phosphorus, and magnesium content in the corn leaves. These constituents were all lower than the expected concentration. The barley leaves contained more cadmium and lead; that is, the cadmium content in the leaves was 2.0 mg/kg as opposed to the expected range of 0 to 1 mg/kg, and the lead was 14.0 mg/kg, whereas the expected range was 0 to 10 mg/kg.

The cotton leaves and petioles, grown on the control site, were higher than the expected range for cadmium (4.7 mg/kg as opposed to 0 to 3 mg/kg range), chromium (1.7 mg/kg, whereas the expected range was 0 to 1 mg/kg), molybdenum (33 mg/kg as opposed to 1 to 10 mg/kg range), nickel (9.3 mg/kg rather than the 0 to 2 mg/kg as compared to a 0 to 10 mg/kg range). The lead content in the cotton tissues was the highest found for any of the crop tissues. The sudan grass blades were not significantly high in any constituents except iron (655 mg/kg) and manganese (131 mg/kg).

From the crop tissue analyses, it appeared that the treated effluent irrigation had little, if any, impact on the accumulation of elements in the crop tissues. In fact, there was more of the excessive uptake of constituents in the control site grown cotton than in the crops grown on the test soil.

Water Balance

The water balance estimate for the test and control site is given in Table 32. The precipitation data was obtained from the nearby Phoenix Airport weather station. It was assumed that 25 percent of the treated water was lost by evaporation and percolation in the treatment plant storage holding ponds, and from irrigation runoff which was by-passed into the Salt River bed. "Potential evapotranspiration" is defined by Thronthwaite as "the water loss which will occur if at no time there is deficiency of water in the soil for the use of the vegetation (25)." It is herein determined as the sum of evapotranspirative data for sorghum (159.4 cm/hectare - summer) and barley (158.7 cm/hectare - winter) crops (26). The "balance" is the leachate percolating into the groundwater. The evapotranspiration data for the control site milo sorghum, barley, cotton, alfalfa, wheat, sugar beet seed, and sudan grass crops were based on conventional local experience.

Agricultural Balances and Comparisons

The agricultural history of the test and control sites' usage for the period 1965 through 1977 were presented in Tables 28 and 29. Table 33 shows the pesticide applications for the test and control sites during the 1965 to 1975 decade. This table also compares the actual reported application rates with those recommended by the manufacturer.

The estimated total quantity of the nutrients, nitrogen, phosphorus, and potassium for the test and control sites is presented in Table 34. The nutrient balances compare

TABLE 31 . EXPECTED RANGE OF ELEMENTS IN HEALTHY CROP TISSUE[a]

Crop	Constituent (mg/kg) As	B	Cd	Cr	Cu	Mo	Ni	Pb	Se	Zn
Broccoli	0-1	10-50	0-3	0-1	1-20	1-50	0.1-3	0-10	0-2	30-100
Corn	0-1	10-50	0-3	0-3	1-30	1-5	0-3	0-10	0-1	20-200
Cotton	0-1	10-50	0-3	0-1	1-30	1-10	0-2	0-10	0-1	10-200
Forage	0-1	10-100	0-3	0-1	1-10	1-5	0-5	0-5	--[b]	20-100
Small grain	0-2	10-60	0-1	0-1	1-40	1-10	--	0-10	--	30-100
Sorghum	0-1	10-70	0-3	0-2	1-30	1-5	0-3	0-10	0-1	10-100
Spinach	0-1	10-70	0-3	0-1	1-20	1-10	0.1-1	0-10	0-1	30-150
Tomato	0.01-1	10-100	0-3	--	1-30	0.7-5	0-3	1-10	0-2	40-200

Crop	Constituent (% or 10_4 mg/kg) Ca	K	Mg	N	Na	P
Broccoli	0.1-1.5	1-3	0.5-1.5	1-3	--	0.3-1
Corn	0.1-1.5	1-2	0.5-1.5	1-2.5	--	0.1-1.5
Cotton	0.5-1.5	0.7-1.5	0.2-1	0.4-1.5	--	0.5-1
Forage	0.2-1.2	0.1-1	0.1-1	0.2-0.7	--	0.2-1
Small grain	0.4-1	1-3	0.2-1	0.4-1	0.04-1	0.2-1
Sorghum	0.1-1.5	1-2.5	0.5-1.5	0.5-2.5	--	0.1-1.5
Spinach	0.1-2	1-3	0.5-1.2	1-3.5	--	0.3-1
Tomato	1-2.5	0.2-1	0.7-1.5	1-3	--	0.3-1

[a] Sources: 6-24.

[b] Not determined.

TABLE 32. WATER BALANCE - YEARLY AVERAGE FOR PERIOD 1965 TO 1977

Site	Precipitation			Irrigation		Total Effective Water (cm) F[e]	Average Evapo- transpiration (cm)[d] G	Average Leachate (cm) H[f]
	Total (cm) A	Effective[a] (cm) B	Total 1,000 cu m) C	Total[b] (cm) D	Effective[c] (cm) E			
Control[g]	20	18	216	172	168	186	119	67
Test[h]	20	18	189	609	502	520	129	391

[a] Runoff coefficient is percent of precipitation lost through runoff, runoff coefficient: 0.1

[b] Estimating that 8000 m^3 per day of the treated effluent is diverted by percolation, evaporation, etc.

[c] Irrigation efficiency, the percent of total applied which is not lost to runoff, was estimated to be 82 percent.

[d] Source: 27.

[e] F = B + E

[f] H = F - G

[g] Area: 12.6 ha

[h] Area: 3.1 ha

TABLE 33 . CONTROL AND TEST SITES PESTICIDES APPLICATIONS, 1965-75[a]

Description	Crop[b]	
	Wheat	Sugar Beet Seed
Common Name[b]	Orthotoxaphene	Sulfur
Chemical Name[c]	Toxaphene	Sulfur
Manufacturer[c]	Chevron	
Insecticide or Pesticide[c]	Insecticide	Pesticide
Recommended Application Rate (l/ha, unless otherwise noted)[c]	4	16-18 kg[d]
Rate of Application (l/ha, unless otherwise noted)[b]	3.5	18 kg[d]
Number of Applications[b]	1	1[d]
Contact Time (days)	14	No limitation
Remarks[c]	Do not feed cattle, toxic to birds, cattle, and wildlife. Can contaminate water bodies.	Avoid drift

[a] No pesticides were used by the test site farmer between 1965 and 1975.
[b] Supplied by site farmer.
[c] Obtained from 1976-77 Publication Q-13, Cooperative Extension Service, Univ. of Arizona.
[d] Manufacturers recommendations (first column shows reported actual pesticide usage.)

Note: No other pesticides were used by the control site farmer during the period between 1965 and 1975.

TABLE 34 . SUMMARY NUTRIENT BALANCE (1965-77)

Input/Output	Total Nutrient (kg/ha					
	Test Site			Control Site		
	N	P	K	N	P	K
Inputs						
Fertilizer	N.U.[a]	N.U.	N.U.	1,830	261	0
Irrigation	16,321	6,527	13,054	1,122	136	1,572
Total input	16,321	6,527	13,054	2,952	397	1,572
Output						
Crop uptake	3,830	1,180	1,740	1,845	545	711
Leachate	23,593	2,540	8,135	1,666	351	1,403
Atmosphere	650	0	0	130	0	0
Total output	28,073	3,720	9,875	3,641	896	2,114
Topsoil residual	-11,752[b]	2,807	3,179	-689[b]	-499	-542

[a] N. U. = None used.

[b] Negative value indicates topsoil depletion of nutrient and does not represent the actual value.

the reported amounts of the total applied nutrients by conventional Salt River water supply versus effluent irrigation; the amounts of fertilizer nutrients for the test versus the control sites; the total nutrients applied to both the test and the control sites, and the nutrient residual present in the topsoil (after losses) for the test and control sites. No fertilizer was reported to have been used on the test site. The results indicated that there was a net depletion of nitrogen in the test site soil, and of nitrogen and phosphorus in the control site soil. Although the irrigated effluent provided about six times as much nitrogen as was put onto the control site, nitrogen was lost in the leachate. The nitrogen depletion of the soil may have been due to leaching at the test site by the high rates of wastewater irrigation. Considerable nitrogen (60-70 mg/l) was present in the leachate. Additional nitrogen was lost in the drainage runoff (about 10 percent of the total effluent applied).

The historical effects of the nutrients on crop yield and nutrient uptake efficiency are presented in Appendix G, and summarized in Table 35 for the thirteen-year period from 1965 through 1977. The control site nutrient uptake efficiencies were more than triple the uptake efficiencies on the test site both for all the different crops grown and for the identical crops. However, the quantity of nutrients taken up by crops at the test site was greater than at the control site. These results can be explained as probably due to the high nutrient input on the test site which exceeded the requirements for the planted crops.

Economic Analysis

The estimated maximum imputed values of nutrients in the wastewater and irrigation water that were estimated to be used by the crops at the test and control sites are given in Table 36. It was assumed that the test site crops received all of their applied nutrients from the wastewater. In the above analysis the nutrients removed from the soil were not considered since the actual amount from each source was not known.

A summary of the costs and sales of crops from the test and control sites is given on Table 37. The crops grown on the test site were more profitable per hectare than those grown on the control site. Fertilizer and irrigation water costs at the control site were responsible for the lower profits. The fertilizing costs included both the fertilizer purchase and the application costs.

The annual commercial value of the nutrients in the wastewater effluent applied at the test site were estimated to be as follows: 1977 - $1,199; 1976 - $1,315; 1975 - $1,964. The Salt River irrigation water fertilizer values at the control site were estimated to be as follows: 1977 - $200; 1976 - $207; and 1975 - $124. These values are based on the cost of an equal quantity of nutrients if purchased as commercial fertilizer. However, the actual useful fertilizer value was lower, since only a portion of the nutrients were consumed, but this was also true, in part, for conventional commercial fertilizer usage.

TABLE 35. SUMMARY OF CROP YIELD AND NUTRIENT UPTAKE (1965-77)[a]

Site	Estimated Nutrient Supplied (kg/ha/yr)			Estimated Nutrient Uptake (kg/ha/yr)			Uptake Efficiency %			Combined Nutrient Uptake Efficiency %	Crop Yield 1,000/kg/ha/yr
	N	P	K	N	P	K	N	P	K		
Test	1,255	502	1,004	295	91	134	24	20	16	20	4.0[b] 2.0[c] 5.8[d] 0.7[e] 17.0[f]
Control	218	31	121	140	43	54	61	94	48	68	2.2[g] 3.4[h] 6.9[i] 0.7[j] 4.0[k] 3.0[l] 4.7[m]

[a] Yearly average during thirteen year period.
[b] Bermuda grass: 1965 to 1972.
[c] Wheat: 1972.
[d] Sorghum: 1973 to 1976.
[e] Barley: 1974 to 1977.
[f] Corn: 1974,1975,1977.
[g] Barley: 1965 to 1966.
[h] Sorghum: 1965,1967,1970.
[i] Cotton: 1966,1967,1977.
[j] Alfalfa: 1968,1969,1974.
[k] Wheat: 1970,1971,1975.
[l] Sugar beet: 1971,1972.
[m] Sudan grass: 1973,1975,1976.

TABLE 36. VALUE OF WASTEWATER NUTRIENTS (1965-77)

Nutrient Source/Use	Test Site				Control Site		
	N	P	K		N	P	K
Fertilizer supply (kg/ha)	0	0	0		1,830	261	0
Crops uptake (kg/ha)	3,830	1,188	1,740		1,845	545	711
Net supplied by wastewater[a] (kg/ha)	3,830	1,188	1,740		15	284	711
Maximum value of nutrient supplied by irrigation[b] ($/ha)	2,528	784	1,148		30	187	469
Total value of N, P, and K (1965-1977) ($ /ha)				4,460			
Avg total value of N, P, and K per year ($ /ha)				343			

[a] Assumes that all of the crop uptake in excess of fertilizer applied was from wastewater or irrigation water. Some of the nutrients may come from the soil, but the amount is not known.

[b] 1965 to 1977 total value.

TABLE 37 . TEST AND CONTROL SITES, CROP COSTS, AND SALES COMPARISON ($/ha)[a,b]

Year 19__	Site & Crop[c]	Cultivation	Irrigation Water	Fertilizing[d]	Harvesting, Packaging, & Selling	Land	Total Costs	Crop Sales Price	Estimated Profit
77	Test Site								
	Barley, silage	103	0	0	123	64	290	402	112
	Corn, silage	88	0	0	116	64	268	931	663
	Control Site								
	Cotton	260	218	72	595	408	1553	1,384	-169
76	Test Site								
	Barley, silage	94	0	0	112	64	270	452	187
	Sorghum, silage	238	0	0	82	64	384	455	71
	Control Site								
	Sudan grass (year round)	146	132	97	126	408	909	1067	158
75	Test Site								
	Barley, silage	85	0	0	102	64	251	480	229
	Corn, silage	73	0	0	97	64	234	835	601
	Sorghum, silage	70	0	0	92	64	226	413	187
	Control Site								
	Sudan grass	67	97	92	88	204	548	534	-14
	Wheat	132	66	111	99	204	612	568	-44

(continued)

TABLE 37 (continued)

[a] This Table is based on 1975-1978 costs. Costs for the years 1965-1974 would be relatively similar, but vary with the economic factors for those years.

[b] From 1976, 1977 Arizona Field Crop Budgets, Maricopa County, Cooperative Extension Service, University of Arizona.

[c] Test site crops were used as animal forage while control site crops varied in nature.

[d] From Appendix G on nutrient balances for Mesa, Arizona sites.

Note: All numbers rounded off to nearest whole number.

OTHER ENVIRONMENTAL OBSERVATIONS

The following are general observations which were noted during the duration of this study. The treatment plant facility and the test and control sites were fenced. The warm raw sewage entering the City of Mesa wastewater treatment plant contained sufficient concentrations of sulfides and related decomposition products so that some odor existed; however, the secondary effluent used for the test site irrigation was stabilized and did not contribute to the sulfide related odors. The secondary effluent was somewhat turbid and not very transparent. The turbidity was generally caused by the suspended trickling filter organic floc and pond algae growths present in the effluents. Residents lived within about 300 meters of the treatment plant, and the test and control sites. During warm periods when a low velocity wind blew, some minor odor-related observations were made by the neighboring residents. These odors were attributed primarily to the raw septic sewage entering the facility, and the sludge storage lagoons, rather than the reclaimed effluent irrigated on the test site. The dry, windy weather in Maricopa County, aided in dissipating and minimizing any odor problem. The secondary effluent was not chlorinated, and this resulted in the presence of high coliform counts on the test site, when compared with the control site. However, the water qualify was satisfactory for good crop growth. Also, as reported earlier, most of the micro-biological organisms were not detected in the soil below a 100 cm depth, nor was there any effluent related microorganisms found in the groundwater. During the duration of this study, there were no reported health hazards or illnesses attributable to the reclaimed effluent irrigation water used on the test site. Some of the effluent irrigated land had a history of dairy farming. There were no reported problems with the cows or the milk dueto effluent irrigation.

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APPENDIX A

SITE DESCRIPTION

GENERAL AREA CHARACTERISTICS

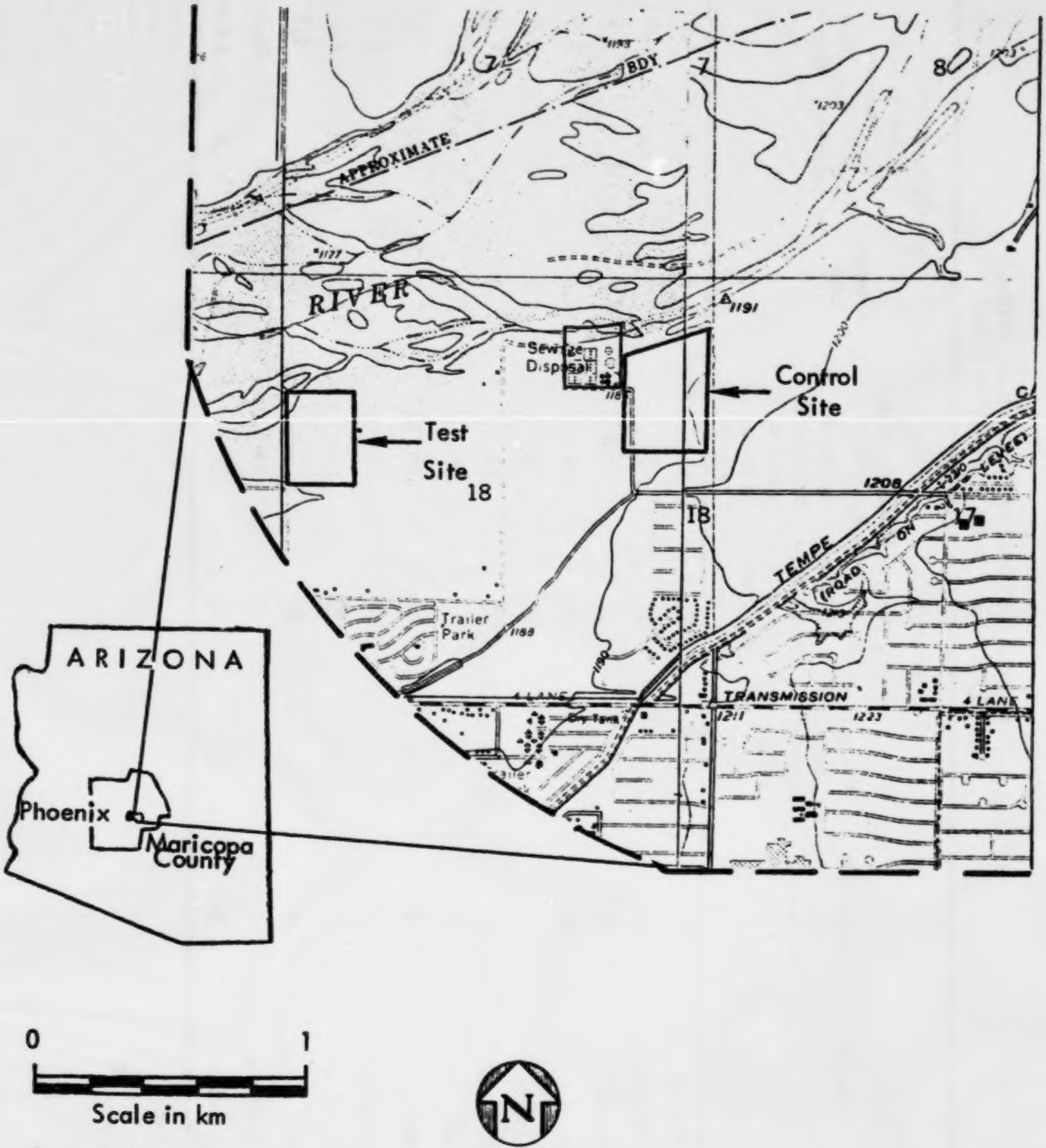
Introduction

The City of Mesa wastewater reclamation project area was situated in Maricopa County, Arizona, approximately 6 miles southeast of Phoenix. Location of the two sites and sewage treatment plant are shown in Figure A-1. The principal historical use of the site has been for agriculture. The following sections consider relevant factors about the local environment, agricultural practices, and wastewater treatment.

Climate

The project area has an arid climate. Average monthly precipitation exceeds 2.5 cm only during August and December. Rains in summer are frequently associated with thunderstorms that form over the mountains to the east during the afternoon and spread out over the surrounding valley early in the evening. Precipitation tends to be moderate to heavy for short periods and rarely lasts more than 30 minutes. Many times, local storms produced little more than gusty winds and minor precipitations. In some years, however, weak tropical disturbances moving northward from the Pacific Ocean cause unusually large amounts of precipitation with prolonged wet periods occuring during the summer. These unusual storms have produced rainfall during a 24-hour period equal to that normally received during an entire summer. Table A-1 presents historical temperature and precipitation data for the project area, obtained from a weather station at the Mesa Experimental Farm. This data is considered to be representative for the project area. Table A-2 gives the probabilities of having freezing temperatures at specific dates in spring and fall.

Precipitation is less dependable in the winter than in the summer, and the quantity varies from year to year. Most winter precipitation is associated with the middle-latitude storms that move inland from the Pacific Ocean. The most severe weather occurs either when these storms move unusually far south or when they have been intensified off the coast of southern California. Then, cloudy skies and intermittent showers occur for days. Snow is rare in the project area. During December, January, and February, traces of snow may be observed at the Granite Reef Dam and at the Mesa Experiment Farm, but the snow usually melts soon after falling.


BDY
7
8
APPROXIMATE
1177
RIVER
1191
Sewage Disposal
Control Site
Test Site
18
1208
TEMPE
ROAD
ON
LEVEE
17
Trailer Park
1188
TRANSMISSION
4 LANE
1211
1223
ARIZONA
Phoenix
Maricopa County
0
1
Scale in km
N

Source: 1

Figure A-1. Study area - test and control farm sites.

TABLE A-1 TEMPERATURE AND PRECIPITATION, 1928-67 MESA EXPERIMENT FARM (ELEVATION 375 m)

Month	Temperature (°C)				Precipitation (cm)		
			2 years in 10 will have at least 4 days with--			1 year in 10 will have--	
	Average daily maximum (°C)	Average daily minimum (°C)	Maximum temperature equal to or higher than--	Minimum temperature equal to or lower than--	Average total	Less than--	More than--
January	18	1.6	25	-3	2.0	[a]	4.3
February	20	2	27	-2	1.5	[a]	4.0
March	23	6	29	1.6	1.7	0	4.3
April	28	10	35	5	0.7	0	3.5
May	33	12.7	39	8	0.2	0	2.0
June	38	17	43	12	0.2	0	1.2
July	40	23	43	19	2.0	[a]	5.3
August	39	22	42	19	3	0.5	7.6
September	37	19	41	13	1.7	[a]	5.3
October	31	12	38	6	1.2	[a]	4.3
November	24	5	28	1.6	1.2	0	3.3
December	19	2	24	-22	2.5	0	10.1
Year	29	11	44	- 5	18.5	10.4	27.9

[a] Trace.

Source: 28

TABLE A-2. PROBABILITIES OF FREEZING TEMPERATURES ON SPECIFIC DATES MESA EXPERIMENT FARM, 1936-65

Probability	Dates for stated probability and temperature			
	-6°C or lower	-4°C or lower	-2°C or lower	0°C or lower
Spring:				
1 year in 10 later than	January 19	February 10	March 13	April 7
2 years in 10 later than	(a)	January 30	February 28	March 27
5 years in 10 later than	(a)	(a)	February 8	March 3
Fall:				
1 year in 10 earlier than	January 10	December 12	November 8	November 2
2 years in 10 earlier than	(a)	December 21	November 19	November 9
5 years in 10 earlier than	(a)	(a)	December 14	November 24

[a] Threshold did not occur frequently enough during period of record to compute this probability level.

Source: 1.

Summers are warm. From early June until late September, the average daily temperature is higher than 26° C, ranging from about 21° C near sunrise to 37° C in early afternoon. Readings of 43° C or higher, occur regularly between the last week in June and the beginning of the rainy season in summer. During this latter period, the air is normally dry. The warm days are generally followed by cool evenings, during which time the temperature often drops to about 15° C.

From late fall until early spring, the climate is normally mild. In winter the temperature ranges from 0° to 40° C near daybreak, to about 20° C in the afternoon. During warmer periods, the maximum temperature in the afternoon exceeds 26° C. Freezing temperatures are rare, and occur on about 15 mornings annually. Readings of below -6° C are unusual.

The length of the frost-free period can be computed from Table A-2. This table gives the probabilities that a stated temperature will occur before or after a specified date. In 1 year in 10, for example, a temperature of 0° C or lower in spring will probably occur earlier than December 11.

In the spring, winds from the southwest and west are predominant, particularly during periods of low-pressure troughs. When thunderstorms occur, local winds are often gusty, and usually flow in an easterly direction. Periods in which winds are less than 16 km per hour occur throughout the year, and are often several days in length.

About 86 percent of the total available sunshine reaches the ground surface. The amount ranges from a minimum monthly average of 77 percent in December and January to a maximum monthly average of 94 percent in June.

Geology

The project area is located in the Salt River Valley which is an alluvial valley bounded by a northwest trending mountain group to the northeast, a north-south trending group to the west, and an east-west trending group to the south. The alluvium consists of a clay, salt, sand, gravel, and boulder sequence which thickens to over 370 m in the center of the valley (27). The surrounding mountains are composed of granite and schist of the Precambrian age, conglomerate of the Cretaceous-Tertiary age, and andesite of the Tertiary age (28).

Soils

The physiographic feature that formed the transitional area between the mountains and valley is a waste apron composed of detritus that has eroded from the highlands. Deposits of rubble, gravel, and sand are at the upper end of the apron where the soils are moderately sloping to strongly sloping. Slightly farther down the apron has mostly gently sloping Covelt, Pinamt, and Tremont soils. Still farther down are nearly level or gently sloping Anthro and Valencia soils, and at the extreme lower end are nearly level Mohall, Contine, and Vecont soils.

Superimposed on the soils at the lower end of the apron, and in areas cut into these soils, are areas of recent soils that were formed in alluvium deposited by streams on flood plains and recent alluvial fans. Adjacent to the streams are Agualt, Vint, Gilman, Avondale, Pimer, and Glenbar soils. On terraces along some of these streams are Laveen, Pinal, and Rillito soils. Predominating at the project site are soils of the Vint, Gilman, Pimer, and Avondale series.

The major stream is the Salt River which is normally dry, and which was once a perennial stream before upstream dams were constructed in the mountains. The parent material of the soils in the project area was derived from the mountains adjacent to the Salt River Valley. These included the Phoenix, Salt River, San Tan, Superstition, and Goldfield Mountains, consisting mainly of granite, schist, and andesite, with some diorite and tuff. Most of the soils in the project area were formed in mixed alluvial material that is several meters thick. The soils in the project area are considered young or immature because of their relatively short geological development time.

Hydrogeology

The project area is located in the Salt River Valley hydrologic unit (27) which is a part of the Basin and Range Lowlands water province. Groundwater is contained in the alluvial deposits of the valley which are composed of interbedded coarse sands, gravels, and boulders, and fine-grained material. Water levels in 1975 and 1976 in the Salt River Valley varied from 100 to over 500 feet depth below the ground surface (29). Groundwater levels have dropped an average of 35 feet since 1940 (30) due to:

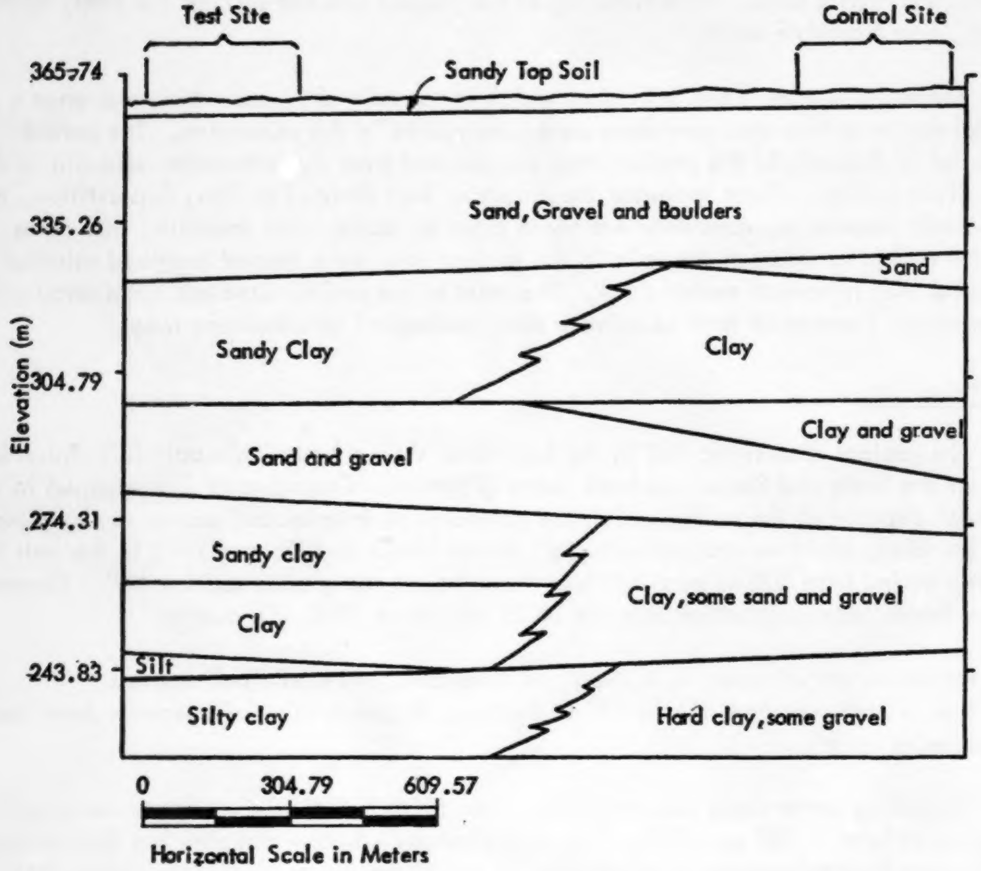
1) Extensive use of water for agriculture, industry, and municipal supplies.
2) Loss of recharge from the Salt River because of construction of upstream dams and diversion of canals.

Producing water wells generally draw from 50 to 2,500 gpm with most deep wells drawing at least 1,000 gpm (29). The extensive groundwater pumping has also caused, in some areas, land subsidence of as much as 30 to 150 cm due to hydrocompaction (31).

Underlying the project area are interbedded layers of sand, gravel, boulders, silty clays, and clays (see Figure A-2). Generally, the 180 to 360 cm topsoil layer is underlain by a sand-gravel-boulder layer which was continuous over the area (as determined from available well logs) and ranges from 33 to 47 m in thickness. Historically, these layers have been water-bearing. Beneath the gravel-sand lie clay-silt layers which may perch some leachate or other water. These layers are continuous over the area and range in thickness from 17 to 106 m. They exhibit lateral variability, becoming thinner and coarser (containing gravel) eastward and northward, and thickening southward.

Groundwater

Municipal and agricultural water services are obtained from the Apache and Roosevelt reservoirs located to the east, and from local wells. General characteristics


Test Site
Control Site
365.74
Sandy Top Soil
Sand, Gravel and Boulders
335.26
Sand
Elevation (m)
Sandy Clay
Clay
304.79
Clay and gravel
Sand and gravel
274.31
Sandy clay
Clay, some sand and gravel
Clay
Silt
243.83
Silty clay
Hard clay, some gravel
0
304.79
609.57
Horizontal Scale in Meters

Source: Well Logs

Figure A-2. Mesa, Arizona, Idealized Cross-section of Project Area.

of groundwater quality in the Mesa-Tempe, Arizona area for 1974 (32) were:

1) Hardness generally exceeded 150 mg/l (as calcium carbonate).
2) Total dissolved solids generally fell between 500 mg/l and 1,000 mg/l.
3) Nitrates were less than 45 mg/l.
4) Fluorides were less than 1.4 mg/l.

Agriculture

Agriculture in the project area is adapted to slight rainfall, irrigation during the hot-dry summer, and a long growing season. Most soils need greater organic content to reduce tillage and compaction, as well as nitrogen and phosphorus. Among the principal crops under irrigation are cotton, sorghum, barley, alfalfa, sugar beets, wheat, safflower, and citrus. Information on water use by crop is summarized in Table A-3.

Table A-4 shows predicted average hectare yields of the principal irrigated crops grown on the aerable soils under a high level of management. These predictions are based on observations made by the personnel of the Soil Conservation Service, the Agricultural Stabilization and Conservation Service, and the University of Arizona Agricultural Extension Service. These estimates varied for different soils and crops. Representative data on evapotranspiration for citrus, cotton, alfalfa, flax and date crops in the Mesa, Arizona area are given in Tables A-5 through A-9.

The use of water for soybeans, sorghum and guar were determined at the University of Arizona Farm at Mesa (33). Seasonal transpiration uses are: (1) soybean, 55 cm; (2) sorghum, 51 cm; and (3) guar, 40.5 cm. The daily rates at which plants used water were computed for the nine crops grown in Maricopa County, Arizona. The computations are shown in Table A-10. This data was used to evaluate crop irrigation requirements and related water balances at the Mesa, Arizona study site.

Wastewater Treatment

The project wastewater treatment facility is owned and operated by the City of Mesa and discharged an average flow of 6.3 million cubic meters per year, with a peak flow of 7.5 million cubic meters per year. The sequence of treatment consists of primary sedimentation, trickling filter, secondary settling, and two holding ponds. Sludge is dried and landfilled. A portion of the effluent is used for agricultural irrigation at the test site. Table A-11 summarizes those effluent water quality characteristics determined by the treatment plant. Table A-12 lists the total yearly flows from 1966 through 1976, and the effluent available for irrigation (assuming 25 percent evaporative and holding pond exfiltration).

TABLE A-3. MARICOPA COUNTY, ARIZONA, CHARACTERISTICS OF WATER USE BY CROPS[a]

Crop	Season	Mean Water Use (cm) Seasonal Use	Peak Use Per Day
Bermuda lawn	May - October	110.5	,8636
Cotton	April - November	105.7	.9652
Alfalfa	February - November	188.7	.9398
Barley	December - May	64.3	1.016
Grain-Sorghum	July - October	54.5	1.09
Sorghum (double crop)	April - December	130.8	1.143 1.016
Sugar beets	October - July	108.7	.762
Wheat	January - May	58.2	1.016
Safflower	January - July	115.3	1.1938
Corn silage	March - July	49.8	1.0922
Citrus	January - December	100.8	.4572

[a] Consumptive use of water by crops in Arizona, Agricultural Experiment Station, University of Arizona, 1976.

TABLE A-4 . PREDICTED AVERAGE YIELDS PER HECTARE OF PRINCIPAL CROPS UNDER HIGH-LEVEL MANAGEMENT

[Data are for arable soils.)

Mapping unit	Capability unit (irrigated)	Cotton (short staple)	Sorghum grain	Barley grain	Alfalfa hay	Sugar beets	Citrus				
								Oranges			
							Grapefruit	Valencia	Navel	Lemons	Tangerines
Avondale clay loam	I-1	3.0	4.25	2.5	8.5	25	16.0	6.7	4.7	17.5	7.0
Gilman fine sandy loam	I-2	3.0	4.0	2.5	8.5	18	16.5	6.8	4.8	18.0	7.2
Gilman loam	I-1	3.0	4.0	2.5	9.0	20	17.0	7.0	5.0	18.5	7.4
Pimer clay loam	I-1	3.0	4.0	2.5	9.0	25	14.5	6.0	4.3	15.8	6.3
Vint loamy fine sand	IIIs-7	2.5	2.5	2.0	6.0	12	12.0	5.0	3.7	13.2	5.3

TABLE A-5. PHOENIX, ARIZONA, MEAN MONTHLY TEMPERATURES AND CONSUMPTIVE-USE FACTOR AND TRANSPIRATION USE FOR NAVEL ORANGE AND GRAPEFRUIT TREES JUNE 1931 TO MAY 1934, INCLUSIVE

Month	Mean temperatures (t)	Daytime hours (p)	Consumptive-use factor (f)	Transpiration use Navel Oranges	Transpiration use Grapefruit
	°C	Percent		cm	cm
January	10	7.13	0.7	2.8	3.0
February	13	6.93	0.9	3.0	3.8
March	18	8.36	1.5	4.2	5.8
April	21	8.79	1.8	6.3	8.3
May	25	9.70	2.4	8.3	10.4
June	30	9.67	2.9	9.9	12.4
July	34	9.86	3.3	11.1	14.2
August	33	9.32	3.1	10.6	14.4
September	30	8.35	2.5	9.6	12.4
October	23	7.91	1.8	6.6	8.6
November	16	7.04	1.1	4.2	5.5
December	11	6.94	0.8	3.0	3.8
Total for year			22.8	79.6	102.6

Annual consumptive use	Orange trees	Grapefruit trees
Transpiration use =	79.6 cm	102.6 cm
Evaporation (estimated) =	17.8 cm	17.8 cm
Total consumptive use (U) =	97.4 cm	120.4 cm

K = Consumptive-use coefficient (orange trees) = $\frac{\text{Consumptive use}}{\text{Consumptive-use factor}} = \frac{U}{F} = \frac{38.6}{73.57} = 0.52$

$K = \frac{U}{F} = \frac{47.6}{73.57} = 0.65$ (grapefruit trees)

F = Sum of f $\qquad f = \frac{t \times p}{100}$ monthly consumptive-use factor

Source: 33.

TABLE A-6. MEAN MONTHLY TEMPERATURES CONSUMPTIVE-USE FACTORS, TRANSPIRATION USE AND PRECIPITATION FOR COTTON 1935-36

Month	Mean temperatures (t)	Daytime hours (p)	Consumptive-use factor (f)	Precipitation (r)	Transpiration
	C°	Percent		cm	cm
April	19	8.79	1.67	0	2.1
May	22	9.74	2.14	T	3.3
June	29	9.68	2.81	T	7.9
July	31	9.77	3.03	4.9	14.5
August	30	9.58	2.87	4.2	18.1
September	27	8.83	2.38	0.62	13.5
October	20	7.81	1.56	1.6	8.2
Total for the period			16.46 (F)	10.7	67.6

Average transpiration for period	= 67.6 cm
Evaporation (6 irrigations at 3/4 inch)	= 10.7 cm
Total consumptive use (U)	= 78.3cm

$K = \frac{U}{F} = \frac{78.3}{16.46} = 4.76$ = average consumptive-use coefficient.

t = mean monthly temperatures.

p = monthly percent of daytime hours of year.

$f = \frac{t \times p}{100}$ = monthly consumptive-use factor.

F = sum of f = consumptive factor for period.

Source: 33.

TABLE A-7. MEAN MONTHLY TEMPERATURES PERCENT OF DAYTIME HOURS CONSUMPTIVE USE FACTOR, CONSUMPTIVE USE, AND CONSUMPTIVE USE COEFFICIENT FOR ALFALFA, AVERAGE 1945-46

Month[a]	Mean temperatures (t)	Daytime hours (p)	Consumptive use factor (f)	Consumptive use (u)	Consumptive use coefficient (K)
	C°	Percent		cm	
January	9	7.13	.64	2.5	3.97
February	11	6.93	.76	5.1	6.71
March	14	8.36	1.17	8.9	7.61
April	19	8.79	1.67	12.7	7.61
May	23	9.70	2.23	16.5	7.40
June	28	6.67	1.87	22.8	12.25
July	32	9.86	3.16	30.5	9.65
September 15-30	28	8.34	2.34	7.6	3.25
October	21	7.91	1.66	10.2	6.15
November	13	7.04	.92	7.6	8.26
December	10	6.94	70	5.1	7.3
Total			17.12 (F)	139.64 (U)	

[a] Rest period August 1 to September 15.

$K = \frac{U}{F} = \frac{129.64}{17.12}$ 7.57 consumptive use coefficient for period.

$f = \frac{t \times p}{100}$ = monthly consumptive use factor. $u = kf$ = monthly consumptive use.

F = sum of f = consumptive use factor for period.

Annual consumptive use = 129.64 cm.

Source: 33.

TABLE A-8. MEAN MONTHLY TEMPERATURES PERCENT OF DAYTIME HOURS, CONSUMPTIVE USE FACTOR AND CONSUMPTIVE USE AND CONSUMPTIVE USE COEFFICIENT FOR FLAX 1935-36

Month	Mean temperatures (t)	Daytime hours (p)	Consumptive use factor (f)	Consumptive use (u)	Consumptive use coefficient (k)
	C°	Percent		cm	
October 14-31	21	7.92	1.66	3.8	2.29
November	14	7.05	.99	5.1	5.15
December	11	6.97	.77	6.4	8.31
January	9	7.14	.64	6.4	10.0
February	10	6.93	.69	10.2	14.78
March	13	8.36	1.09	14.0	12.84
April	16	8.78	1.41	17.8	12.62
May	12	9.69	1.16	12.7	10.95
June	25	9.65	2.41	10.2	4.23
Total for period			10.82 (F)	86.6 (U)	

Consumptive use = U = 86.6 cm.

$K = \frac{U}{F} \quad K = \frac{86.6}{10.82} = 8.0$ = consumptive use coefficient for period.

$f = \frac{t \times p}{100}$ = monthly consumptive use factor.

F = sum of f = consumptive use factor for period.

Source: 33.

TABLE A-9 . TEMPE, ARIZONA, MEAN MONTHLY TEMPERATURES, CONSUMPTIVE USE FACTOR AND TRANSPIRATION USE FOR DATES, 1931 - 1932

Month	Mean temperatures (t)	Daytime hours (p)	Consumptive use factor (f)	Transpiration use
	C°	Percent		cm
January	10	7.14	.72	3.05
February	14	6.93	.97	3.81
March	17	8.36	1.42	5.84
April	22	8.78	1.93	8.64
May	26	9.69	2.52	11.43
June	30	9.65	2.90	12.70
July	34	9.85	3.35	14.22
August	33	9.32	3.08	13.72
September	30	8.34	2.5	12.45
October	22	7.92	1.74	10.16
November	16	7.05	1.13	4.83
December	9	6.97	.63	2.54
Total for year			22.89(F)	103.38

Annual transpiration = 103.4
Evaporation = 12.5
Total Consumptive Use (U)= 115.9

$K = \frac{U}{F} = \frac{115.9}{22.89} = 5.06$ = annual consumptive-use coefficient.

Source: 33.

TABLE A-10. MARICOPA COUNTY, ARIZONA, COMPUTED DAILY RATES OF USE OF WATER BY CROPS

Dates	Use of Water (cm per day)[a]								
	Grapefruit	Oranges	Dates	Alfalfa[b]	Cotton	Flax[b]	Sorghum	Soybeans	Guar
Oct. 31						0.147			
Nov. 15						0.170			
Nov. 30						0.190			
Dec. 15						0.210			
Dec. 31	0.112	0.097	0.084	0.084		0.210			
Jan. 15	0.102	0.097	0.109	0.084		0.210			
Jan. 31	0.112	0.097	0.236	0.127		0.274			
Feb. 15	0.127	0.097	0.235	0.170		0.338			
Feb. 28	0.157	0.102	0.254	0.250		0.401			
Mar. 15	0.196	0.122	0.259	0.287	000	0.465			
Mar. 31	0.236	0.145	0.312	0.361	0.084	0.528			
Apr. 15	0.279	0.211	0.356	0.424	0.114	0.597			
Apr. 30	0.310	0.246	0.368	0.488	0.135	0.508			
May 15	0.340	0.276	0.381	0.549	0.216	0.424			
May 31	0.381	0.305	0.392	0.655	0.297	0.381			
June 15	0.414	0.330	0.424	0.762	0.419	0.338		0.170	
June 30	0.445	0.351	0.457	0.889	0.551	0.170		0.272	
July 15	0.475	0.371	0.490	0.102	0.610		0.297	0.373	0.170
July 31	0.478	0.353	0.475	0.910	0.668		0.338	0.465	0.338
Aug. 15	0.493	0.355	0.457	0.810	0.605		0.381	0.559	0.508
Aug. 31	0.450	0.338	0.437	0.740	0.541		0.465	0.533	0.445
Sept. 15	0.414	0.323	0.414	0.510	0.439		0.554	0.508	0.381
Sept. 30	0.351	0.270	0.376	0.475	0.338		0.508	0.381	0.338
Oct. 15	0.338	0.221	0.338	0.338	0.170		0.475	0.245	0.295
Oct. 31	0.235	0.183	0.249	0.295			0.236	0.127	0.147

(continued)

TABLE A-10. (continued)

Dates	Use of Water (cm per day)								
	Grape-fruit.	Oranges	Dates	Alfalfa	Cotton	Flax	Sorghum	Soy-beans	Guar
Nov. 15	0.185	0.145	0.160	0.254					
Nov. 30	0.157	0.122	0.122	0.196					
Dec. 15	0.127	0.102	0.084	0.70					
Dec. 31	0.112	0.097	0.084	0.084					

[a] Transpiration use for all crops except alfalfa and flax
[b] Consumptive use

TABLE A-11. WATER RECLAMATION PLANT YEARLY AVERAGE OF EFFLUENT WATER QUALITY (1966-1975)[a]

Year	BOD, mg/l/day	Suspended Solids mg/l/day	Dissolved Oxygen mg/l/day
1975	40	39	1.9
1974	40	30	2.0
1973	64	35	1.8
1972	64	34	1.5
1971	74	45	1.6
1970	48	34	2.0
1969	44	42	1.9
1968	39	35	1.9
1967	62	45	2.0
1966	70	34	1.8

[a] Secondary effluent, yearly average, obtained from the City of Mesa Wastewater Treatment Plant.

TABLE A-12. TOTAL FLOWS THROUGH WATER RECLAMATION PLANT ($10^6 M^3$)[a]

Year	Flow	Comment	Delivered
1976	4.17	Oct., Nov., Dec. omitted	3.13
1975	6.52		4.89
1974	5.72		4.29
1973	5.28		3.96
1972	6.25		4.69
1971	6.36	12/3-12/17 Repairs	4.77
1970	7.33		5.50
1969	7.47		5.60
1968	7.12		5.34
1967	6.45	No data - January	4.84
1966	6.33	1/1 - 1/9 Flood	4.75

[a] Supplied by the City of Mesa Wastewater Treatment Plant.

TEST SITE

General

The entire Mesa wastewater irrigated site is 44.5 hectares located along the south side of the Salt River, west of the Mesa sewage treatment plant as illustrated in Figure A-1. The wastewater effluent is used in flood and furrow irrigation, and the field runoff is carried through a storm drain into the Salt River. The test site terrain was approximately fifty feet in elevation above the river bed.

Soils

Three types of soils predominated at the test site as indicated on Figure A-3. These are Alluvial land, Vint loamy fine sand, and Gilman fine sandy loam. A general description of these soil types found at the site follows:

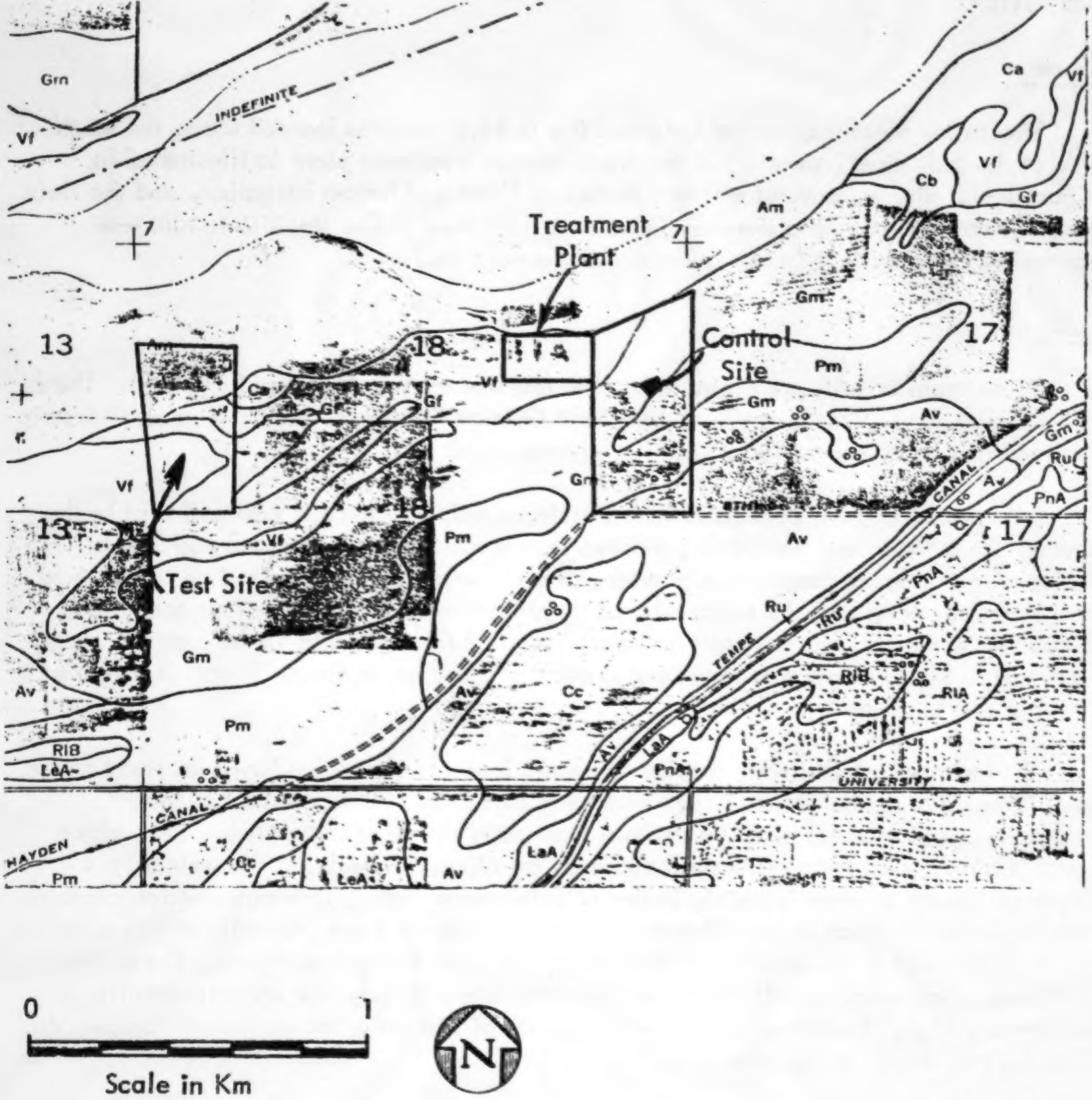
Alluvial land (AM) consists of recently deposited, stratified stream sediment in the Queen Creek Wash and Salt River, derived from a mixture of acidic and basic rocks. Surface layer texture ranges from gravelly sand or very gravelly sand to fine sandy loam. The material underlying the surface layer is very gravelly sand to very fine sandy loam. Permeability ranges from moderate to very high, and the available water capacity ranges from low to high. Roots can penetrate to depths of 150 cm or more. Runoff is slow and blowing soil is generally a hazard.

Vint loamy fine sand (Vf) consists of nearly level, well-drained soils on flood plains and lluvial fans of the Queen Creek Wash and Salt River. It was formed in mixed, coarse-textured alluvial material derived from many different rock types. The surface layer is pale-brown loamy fine sand about 30 cm thick. Underlying the surface to a depth of 150 cm or more is mainly brown or pale brown loamy, fine sand, which contains thin layers of silt loam or very fine sandy loam. These soils are generally mildly alkaline in the upper part of the profile, to moderately alkaline in the lower part. The entire profile is calcareous. Available water capacity is moderately low and permeability is moderately high. Roots can penetrate to a depth of 150 cm or more. Runoff is slow, and blowing soil is only a slight hazard.

CONTROL SITE

General

The Mesa Control Site is furrow irrigated with fresh water and comprises 12.6 hectares adjoining the treatment plant on the east. The location is shown in Figure A-1. Irrigation water is obtained from the Salt River Project.


Grn
Vf
INDEFINITE
Ca
Vf
Cb
Gf
Am
Treatment Plant
7
7
13
18
Control Site
17
Pm
Gm
Av
Vf
Ca
Gf
Gf
Ru
PnA
CANAL
13
18
Pm
Av
17
Test Site
Ru
TEMPE
RIB
RIA
Gm
Av
Cc
Pm
RIB
LeA
LaA
PnA
UNIVERSITY
CANAL
HAYDEN
Pm
Cc
LeA
Av
LaA
0
1
Scale in Km
N

Source: 28.

Figure A-3. Site soil map

Soils

Four soil types predominated at the control site, as shown in Figure A-3. They were Vint loamy fine sand (Vf), Gilman loam (Gm), Puner clay loam (Pm), and Avondale clay loam (Am). The Vint loamy fine sand is described above. Following is a general description of the other soil types.

Gilman loam (Gm) is found on flood plains and alluvial fans of large streams. The surface layer is pale-brown loam about 33 cm thick. The underlying material is light, yellowish-brown loam extending at a depth of 160 cm thick. The profile commonly contained some fine veins and seams of lime, and is moderately alkaline and calcareous throughout. Available water capacity is high and permeability is moderate. Roots can penetrate to a depth of 152 cm or more. Runoff is slow, and blowing soil and water erosions are not hazards.

Pimer clay loam (Pm) consists of well-drained soil on flood plains and alluvial fans. It was formed in mixed alluvium from igneous rocks. The surface layer is brown, light clay loam and clay loam approximately 68-cm thick. The underlying material is brown clay loam and loam to a depth of 152 cm or more. The profile is moderately alkaline and generally calcareous throughout. Permeability is moderately low, and available water capacity is high. Roots can penetrate to a depth of 150 cm or more. Runoff is slow, and water erosion and blowing soil are not hazards.

Avondale clay loam (Am) consists of well-drained soil deposited on flood plains and alluvial fans of the Salt River. It formed in mixed alluvium derived from rocks. In profile, the surface layer is brown clay loam approximately 33-cm thick. The underlying layers generally consist of brown loam underlain by light-brown very fine sandy loam, extending to a depth of 150 cm or more. These soils are moderately alkaline and generally calcareous throughout. Permeability is moderate, and available water capacity is high. Roots can penetrate to a depth of 150 cm or more. Runoff is very slow, and water erosion and blowing soil are not hazards.

APPENDIX B

SAMPLE COLLECTION AND ANALYTICAL METHODS

SOIL SAMPLE COLLECTION METHOD

Soil samples were collected after the land was prepared (prior to planting) and after the final crop was harvested. Shallow soil samples were taken from the top 100 cm. The rationale was that because the soils were irrigated with wastewater for years, changes in soil strata would occur very slowly in the deeper strata in contrast to the shallower soil. In contrast, the uptake of the nutrients by the root zone of the crops within the first 100 cm could cause significant changes in the upper soil layer.

Collection Procedure

1) Soil samples were collected at both the test and control site locations which received the treated effluent or the regular irrigation water, respectively.

2) For shallow soils, each site was divided into 4 sectors. The center of each sector, if judged to be representative, was selected for sampling. Subsequent samples were taken at randomly selected points located on the perimeter of a circle with a radius of 150 cm and a center at the first sampling point. Samples were taken at locations where plants were particularly large, small, or malformed. No samples were taken at points where unusual plant size was due to an extreme abundance or scarcity of water, such as on the banks of irrigation ditches or at the edge of a field.

(3) Three random locations were selected for deep soil sampling at each site. A 3 meter trench was then dug with a backhoe. Samples were taken at the desired depths from the walls of the trench using proper sterile techniques.

Depth of Sampling

1) Shallow soil samples were taken at the following depths: 0 to 2, 2 to 4, 9 to 11, 29 to 31, and 95-105 cm.

2) Deep soil samples were collected at depths of 195 to 205 cm and 295 to 305 cm.

Sample Treatment

1) Samples for microbiological examination were placed in previously sterilized test tubes. Additional soil was placed into Whirl-Pak bags.

2) Immediately after collecting each sample, the sample containers were marked with pertinent data; including date, location, depth, and site taken.

3) The soil samples were refrigerated in an ice chest containing dry ice while on location. The samples collected at the Mesa sites were shipped to the company's Los Angeles laboratory by air freight.

4) A field activities log (see Table B-1) was filled out at the time of sampling and sent with the samples.

BI-WEEKLY WATER QUALITY SAMPLING PROGRAM

Samples of the irrigation water, the groundwater from the wells, and the leachate from the lysimeters were collected for analyses every two weeks. Two-week composites of the treatment plant effluents were collected by the plant operators. Prior to collection, three bottles were prepared for preservation. For each sample, one bottle was acidified with nitric acid, another with sulfuric acid, and the third was autoclaved. Only one sterilized bottle was provided for each lysimeter sample because of the limited volume of leachate which could be collected. After collecting the sample, each bottle was properly labeled to describe their date, location, depth (if appropriate), and type of preservation. For each sample or group of samples, a field sample report (see Table B-2) was completed and accompanied the shipment of samples to the laboratory. After collection and while in transit, the samples were stored in an ice chest containing dry ice. Upon arrival at the laboratory, the samples were refrigerated at 4° C until analyzed. Specific sampling methods for each type of sample are described below.

Treatment Plant Effluent

1) The treatment plant operator composited a daily sample of secondary effluent over a two-week period. The sample was refrigerated at 4° C during this period of time.

2) The sample was picked up on the same day that the other samples were collected for shipment.

Control Site Irrigation Water Samples

Control site irrigation water samples were collected from the Tempe Canal.

TABLE B-1

FIELD ACTIVITIES LOG

Job No. ______

Collection of Soil Samples for Agronomical Purposes

Shallow & Deep Soil Sample Collection

Please answer in listed units of measure, if possible; if other units are used, specify them. Return completed forms to:

Ralph Stone and Company, Inc.
Los Angeles, California 90025
(213) 478-1501 and 879-1115

1. Site Location: ______________________________
____
____
( ) Test site; ( ) Control site (check one)
2. Observer: ______________________________
3. Date of Observation: ______________ Time: ______________
4. Soil Description
    a. Soil color: ______________________________
    b. Soil type: ( ) loam; ( ) silt; ( ) clay; ( ) sand; ( ) gravel; ( ) other ______
    c. Soil moisture: ______________________________
    d. Soil odors: ______________________________
    e. Soil condition: ( ) hard pack; ( ) loose; ( ) other ______________
    f. Soil surface condition: ______________________________
    g. Date of last soil tillage: ______________________________
    h. Date of last irrigation: ______________________________
5. Depth to Groundwater Table: ______________________________
6. Sample Collection
(Check off ( ) when collected.)
    a. Section 1

	Subsamples									
Depth (cm)	1	2	3	4	5	6	7	8	9	10
0-2										
2-4										
9-11										
29-31										
95-105										
195-205										
295-305										

TABLE B-1 (continued)

b. **Section 2**

Depth (cm)	Subsamples									
	1	2	3	4	5	6	7	8	9	10
0-2										
2-4										
9-11										
29-31										
95-105										
195-205										
295-305										

c. **Section 3**

Depth (cm)										
0-2										
2-4										
9-11										
29-31										
95-105										
195-205										
295-305										

7. Samples Mailed

Date	Time	Shipper

Please use space on reverse for additional comments.

TABLE B-2
FIELD SAMPLE REPORT

Collection of Sample for Analytical Work

Return completed reports with samples to:

Ralph Stone and Company, Inc.
10954 Santa Monica Boulevard
Los Angeles, California 90025

Date: ______________ **Time:** ______________ **Job No.** ______________

Location: ____

Date Last Sample Taken: ________________________________

Weather: ____

Sampler: ____________________ **Observer:** ____________________

Sample Type: ___ wastewater; ___ irrigation water; ___ lysimeter; ___ deep well.

Source: ____

Volume: ____________________ **Odor:** ____________________

Color: ____________________ **Turbidity:** ____________________

Temperature: ____________________ **Bottle coded:** ____________________

Date shipped: ____________________ **Sample in shipment:** ____________________

Remarks: ____

____

____

____

Received by: ____________________ **Checked by:** ____________________

Delivered to lab ____

10/76

Leachate Collection from Lysimeters

1) The protective metal plate placed above the coiled lysimeter lines was located using using a metal detector.

2) The metal plate and lysimeter lines were carefully uncovered using a shovel.

3) A sterilized sample bottle was connected to the proper lysimeter line and the sample collected using a vacuum pump. (See Figure 4, Section 5.)

4) After the sample was collected, the sample bottle was carefully detached from the vacuum line, and a sterilized bottle cap quickly placed on the bottle.

Groundwater Sample Collection

1) A sample for bacteriological analysis from the top and bottom of the groundwater wells was taken first, using a test tube apparatus. The test tube apparatus consisted of a test tube covered by a cone-shaped aluminum foil. A tiny hole at the top of the cone provided an exit for air entrapped in the test tube while holes punched in the lower portion of the cone allowed the sample to enter the tube. A clean string was attached to the test tube to allow the collector to handle the apparatus without contamination. The whole apparatus was sterilized before use.

2) The string was tied to a rope and the test tube apparatus lowered to the desired sampling depth. When the test tube was full, the apparatus was removed from the well, and the foil top replaced with a sterilized test tube cap.

3) The water level in the well was determined, using a steel tape, and then recorded.

4) The water was then evacuated from the well with a submersible pump.

5) When the well had recovered to its previous level, water samples were taken from the top and bottom of the well. Two samples were taken from each depth; one acidified with nitric acid, and the other with sulfuric acid.

COLLECTION OF PLANT TISSUES FOR ANALYTICAL WORK

Tissue Sample Collection

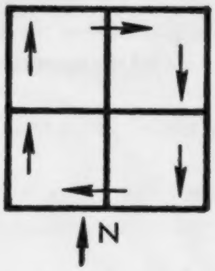
1) Each site was divided into 4 sectors.

2) The sampler started at the center of the southwestern quarter and walked toward the north.

3) While walking, tissues were collected from four to six plants, according to crop and

at 5 randomly selected locations. The fifth sample location was near the center of the northwestern section.

4) From this point, the sampler walked towards the east, taking samples of plant tissues as before. The sampler continued walking and taking random samples of plant tissues, completing the pattern shown in the adjacent diagram.



Time of Sampling

Samples were collected just before harvesting the crop to determine the quality of the crop as was used.

Tissue Sample Collection for Total and Fecal Coliform

1) Just before harvesting, two plants with entire root systems were dug up from 5 locations selected at random in each section.

2) The top portion of the plants were clipped and stored in Whirl-Pak bags.

3) The sterile bags were refrigerated in an ice chest, containing ice, while in transit to the laboratory.

4) Upon arrival at the laboratory, analyses of the samples were begun.

Sample Treatment

1) All the sample bags were identified as to date, location, type of crop, and any other pertinent data.

2) A field activities log (see Table B-3) was filled out at the time of sampling and shipped with the samples.

3) As stated above, all of the plant tissues were refrigerated in the field and were air freighted to the laboratory in Los Angeles.

SOIL TESTING METHODS

Prior to planting, soil samples were collected and analyzed for bulk density, hydraulic conductivity, moisture content, organic content, particle density, and particle size distribution. The test methods used are listed in Table B-4. A field activities log was completed after the soil sample for bulk density was collected (see Table B-5).

TABLE B-3

FIELD ACTIVITIES LOG

Job No. _____

Collection of Plant Tissues for Analytical Work

Please return completed form to:

Ralph Stone and Company, Inc.
10954 Santa Monica Boulevard
Los Angeles, California 90025
(213) 478-1501 and 879-1115

1. Site Location: ____

____

____

( ) Test site; ( ) Control site (check one)

2. Observer: ____

3. Date of Observation: ____________________; Time: ____________________

4. Meteorological Information
(Obtain daily temperature and precipitation data from the nearest recording station. Make a log of system operation for at least a month prior to sampling.)

5. Crop Description
   a. Crop name: ____
   b. Purpose: ____
   c. Crop sowing date: ____
   d. Crop height: ____
   e. Expected date of harvesting: ____

6. Fertilizer Application

Name	Date	Quantity per acre

7. Pesticide, Fungicide, Insecticide Application

Name	Date	Concentration per acre

Please attach copies of available literature on the pesticides, etc., used.

TABLE B-3(continued)

8. Date of Collection: ______________________; Time: Start __________;End ________

9. Tissue Sample Collection
(Check off ( ) when collected.)

Sample	Section 1	Section 2	Section 3	Section 4
1				
2				
3				
4				
5				

10. Tissue Sample Collection for Pathogen Counts and E. Coli
(Collect two plants at five random locations per section, separating the top portion from the root system.)

Sample	Section 1	Section 2	Section 3	Section 4
1a				
1b				
2a				
2b				
3a				
3b				
4a				
4b				
5a				
5b				

11. Samples Mailed
Date: ______________________; Time: ____________; Shipper: ____________

Please use space below for additional comments.

TABLE B-4 SOIL TESTS

Test	Method	Source (page number)
Bulk density	Core	375
Hydraulic conductivity	Constant head	214
Moisture content	Gravimetry, oven drying	92
Organic content	Volatilization, furnace	1,397
Particle density	Pycnometer	371
Particle size distribution	Hydometer	546

Source: 34 and 35.

TABLE B-5
FIELD ACTIVITIES LOG

Job No.____

Determination of Bulk Density of Soil Using Core Method

Samples will be taken at beginning and end of study. Answer in listed units of measure, if possible; if other units are used, please specify them. Return completed forms to:

Ralph Stone and Company, Inc.
10954 Santa Monica Boulevard
Los Angeles, California 90025
(213) 478-1501 and 879-1115

1. Site Location: ____________________

____________________ __________

( ) Test site; ( ) Control site (check one)

2. Observer: ____________________

3. Data of observation: __________; Time: __________

4. Soil Description

a. Soil Color: ____________________

b. Soil Type: ( ) loam; ( ) silt; ( ) clay; ( ) sand; ( ) gravel; ( ) other __________

c. Soil Moisture: ____________________

d. Soil Odors: ____________________

e. Soil Condition: ( ) hard pack; ( ) loose; ( ) other __________

f. Soil Surface Condition: ____________________

5. Depth to Groundwater Table (m): ____________________

Please make additional comments on reverse.

LABORATORY ANALYTICAL METHODS

Many aforementioned chemical and physical analyses were performed on the effluents from the Mesa secondary treatment plant, the irrigation waters, the leachate from the lysimeters, the groundwaters, and the digested and extracted soil and crop samples. All the analyses performed, the methods used, and the references for the methods are shown in Tables B-6 and B-7 and in priorly noted tables.

QUALITY ASSURANCE PROGRAM

An on-going quality assurance program has been maintained to assure the precision and accuracy of the data resulting from the laboratory analyses. Guidelines established by the Analytical Quality Control Laboratory of the United States Environmental Protection Agency have been followed. These included the following:

1) Water samples for chemical analysis were collected according to the American Public Health Association's recommended procedure (36), and preserved by nitric acid or sulfuric acid acidification, and refrigeration at 4° C.

2) Samples were labeled by priority at the time of collection and logged in when received in the laboratory. Physical conditions at the time of sampling were documented.

3) All laboratory personnel complied with minimum educational requirements and were thoroughly trained in the tests which they were assigned to do.

4) Records were kept of all activities in the laboratory. The laboratory work sheets were permanently stored in an indexed binder. The analytical information for reagent preparation, standardizations, etc., were recorded. Instrumental variables, such as the temperatures of the ovens and incubators, or spectrophotometer settings were calibrated against known standards and recorded at the time of testing on a daily basis.

5) Reagent grade chemicals and doubly treated deionized and/or distilled water were used.

6) All reagents and standard solutions were properly labeled and stored.

7) All standards and reagents were replaced on a fixed schedule according to their allowable shelf life and use periods.

8) Conductivity measurements of distilled and deionized water were taken periodically to assure their quality.

9) Instruments were routinely calibrated and maintained according to manufacturers' recommended schedules, or more frequently.

TABLE B-6. SOIL AND CROP PREPARATORY METHODS

Method	Comment	Reference[a] (page number)
Cation exchange capacity	Sodium saturation	899
Exchangeable cations	The decant, diluted to 250 ml in a volumetric flask, was analyzed for potassium, calcium, and magnesium	899
Extraction, water	Soil-to-water ratio of 1:10. Analysis was performed on sample ground with mortar and pestle to pass a 100-mesh sieve	9[b], 935
Extraction, acid	Same as water extraction, except 0.1 N hydrochloric acid was substituted for distilled water.	935
Total digestion	Wet digestion with perchloric-nitric acid and hydrofluoric acid	11[b]

[a] Source: 34.
[b] Source: 37.

TABLE B-7. ANALYTICAL METHODS

Test	Type Water	Soil	Crop	Importance	Rationale	Method	Reference (page number)
Metal							
Arsenic	X	X			May tend to biomagnify	Atomic absorption (gaseous hydride)	95
Barium	X	X	X			Atomic absorption	97
Cadmium	X	X	X	Minor	May tend to biomagnify	Atomic absorption	101
Calcium	X	X	X		Nutrient	Flame emission	103
Chromium	X	X	X			Atomic absorption	105
Copper	X	X	X	Minor	Phytotoxin	Atomic absorption	108
Lead	X	X	X			Atomic absorption	112
Magnesium	X	X	X	Minor	Nutrient, vital to photosynthesis	Atomic absorption	114
Manganese		X	X			Atomic absorption	116
Mercury		X				Cold vapor technique	118
Molybdenum	X	X	X	Minor	May tend to biomagnify	Atomic absorption	139
Nickel	X	X				Atomic absorption	141
Potassium	X	X	X	Minor	May affect plant growth	Atomic absorption	143
Selenium	X	X	X	Minor	Phototoxin, may biomagnify	Atomic absorption (gaseous hydride)	145
Silver		X				Atomic absorption	146
Sodium	X	X	X	Major		Flame emission	147
Zinc	X	X	X			Atomic absorption	155
Physical							
Total dissolved solids	X					Gravimetric	267
Specific conductance^{e}	X			Major	Salinity has major impact on plant response	Electrometric	275

(continued)

TABLE B-7 .(continued)

Test	Type			Importance	Rationale	Method	Reference (page number)[d]
	Water[a]	Soil[b]	Crop[c]				
Inorganic							
Boron	X	X	X	Major	Phytotoxin	Colorimetric (Curoumin)	13
Chloride	X	X	X	Major	Salinity has major impact on plant response	Titrimetric (Mercuric nitrate)	29
Fluoride	X	X		Minor	May tend to bio-magnify	Colorimetric (SPADNS)	59
Nitrogen							
Total Kjeldahl	X	X			Nutrient	Digestion	175
Nitrate	X	X				Colorimetric (Brucine)	197
pH		X				Electrometric	239
Phosphorous					Nutrient		
Total		X	X			Colorimetric (Ascorbic acid)	481[e]
Phosphate	X	X				Colorimetric (Ascorbic acid)	481[e]
Organic phosphate		X				Colorimetric (Stannous chloride)	1038[f]
Sulfate	X		X			Turbidimetric	277
Organic							
Total organic carbon	X					Combustion	236
Microbiology							
Coliform				Major			
Total	X	X	X			Multiple tube fermentation	916[e]
Fecal	X	X	X			Multiple tube fermentation	922[e]
Nematodes		X				Baermann funnel technique	1517[f]
Protozoa		X				Singh method	1513[f]

TABLE B-7 (continued)

---

[a] Water: includes treatment plant effluent, irrigation water, lysimeter leachate, and groundwater.

[b] Soil: includes analyses of soils which were digested, acid and water extracted, and exchanged.

[c] Crops: includes digestion and water extraction of leaves and fruit.

[d] Source: 38 unless otherwise noted.

[e] Source: 36.

[f] Source: 35.

10) Standard procedures (36,38) or other literature sources approved by the United States Environmental Protection Agency, were used. Supervisory personnel provided assurance that the established procedures were strictly followed.

11) A minimum of 10 percent of the samples were duplicated, or were spiked with known amounts of standards.

12) Intermittently, special samples such as distilled water were supplied as routine field collected samples; the laboratory staff knew of this field staff practice. Control charts, based on duplicate and spiked sample results, were used daily to maintain a high quality of work. Samples were rerun if the results of the duplicates and/or spikes were out of the established control ranges.

13) All analytical results were checked by laboratory supervisors and approved by company management.

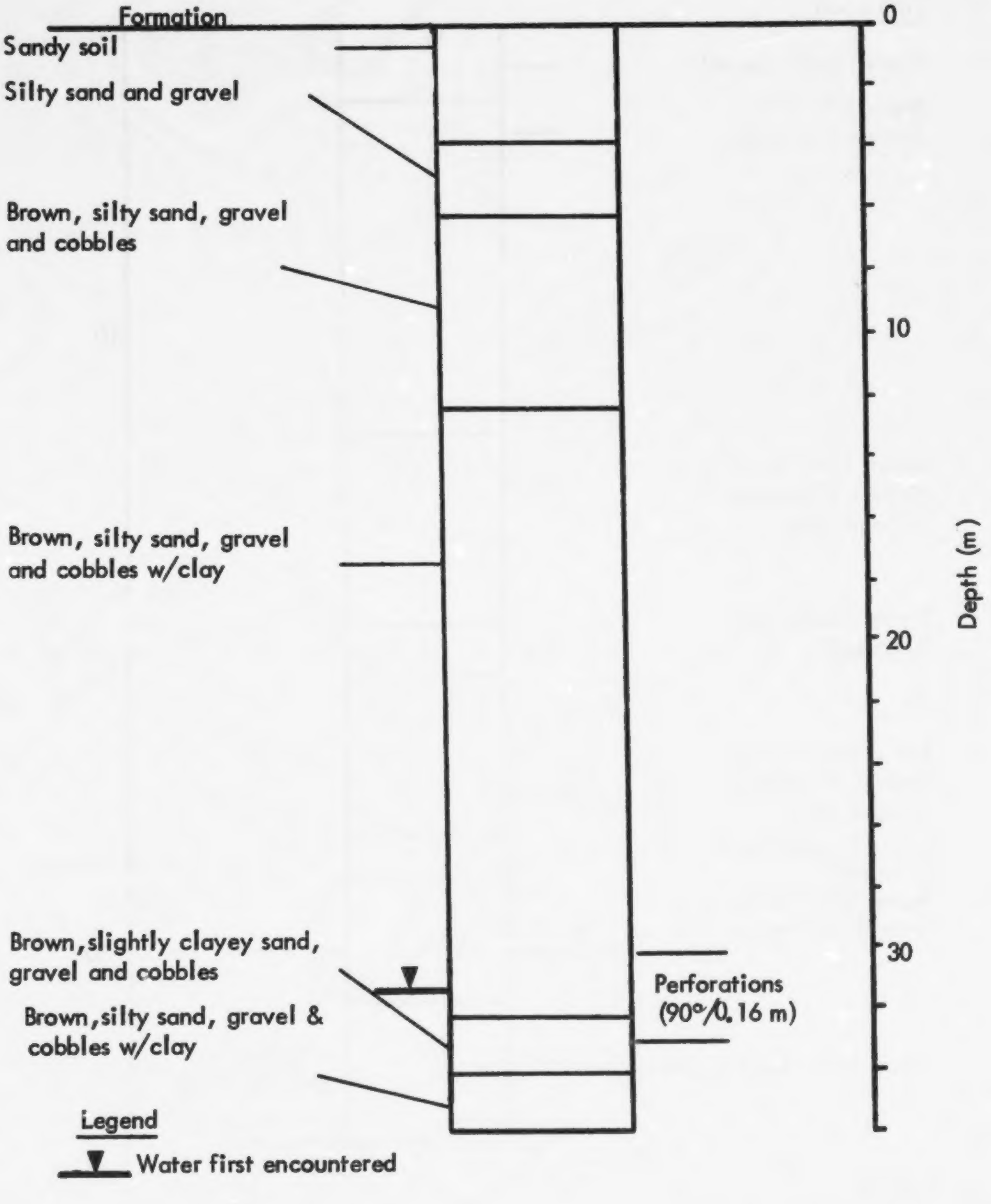

Formation
Sandy soil
Silty sand and gravel
Brown, silty sand, gravel and cobbles
Brown, silty sand, gravel and cobbles w/clay
Brown, slightly clayey sand, gravel and cobbles
Brown, silty sand, gravel & cobbles w/clay
Perforations (90°/0.16 m)
0
10
20
30
Depth (m)
Legend
Water first encountered

Figure C-1. Well log and schematic design of test well 1.

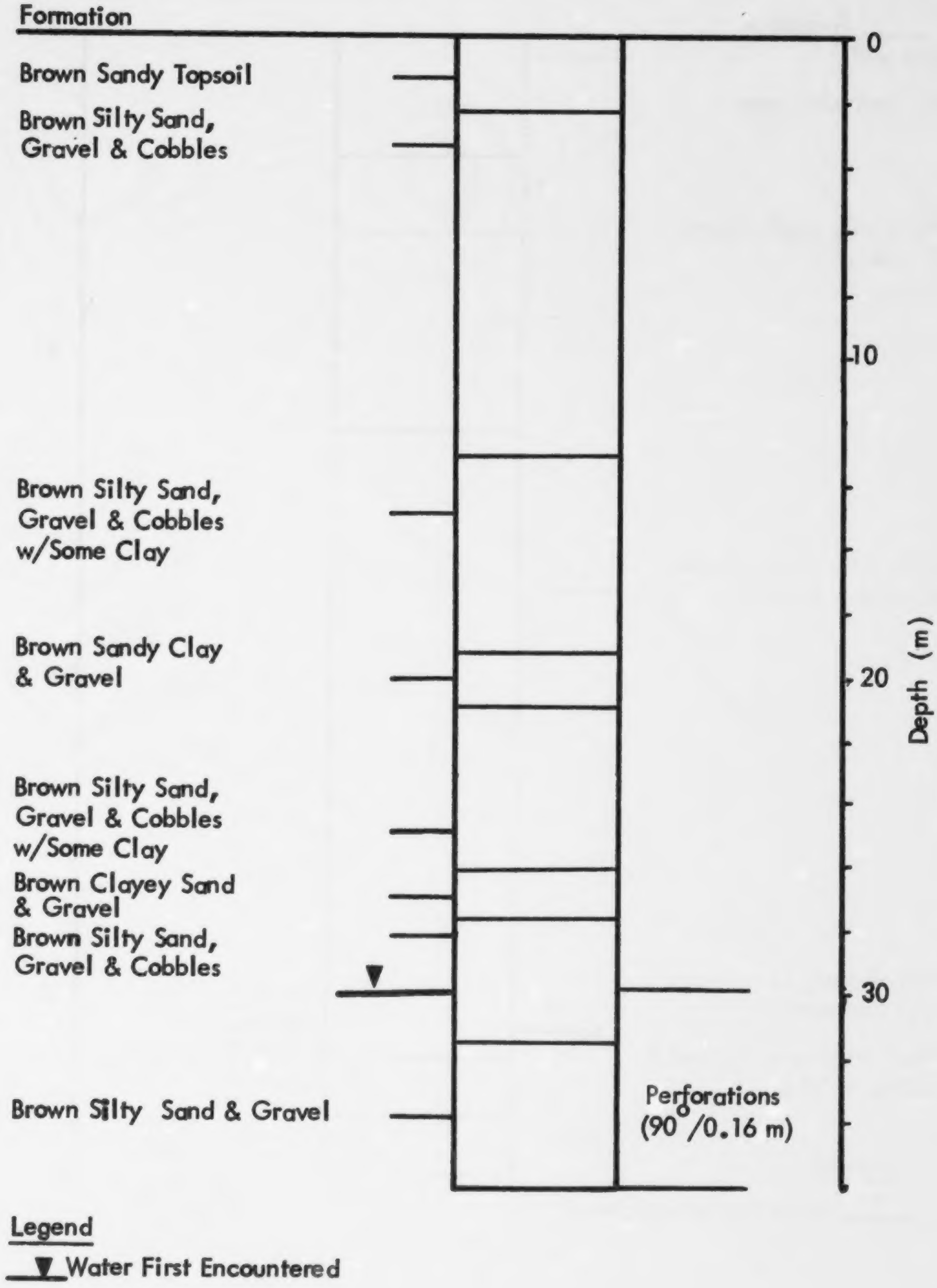

Formation
Brown Sandy Topsoil
Brown Silty Sand, Gravel & Cobbles
Brown Silty Sand, Gravel & Cobbles w/Some Clay
Brown Sandy Clay & Gravel
Brown Silty Sand, Gravel & Cobbles w/Some Clay
Brown Clayey Sand & Gravel
Brown Silty Sand, Gravel & Cobbles
Brown Silty Sand & Gravel
Perforations (90°/0.16 m)
0
10
20
30
Depth (m)
Legend
▼ Water First Encountered

Figure C-2. Well log and schematic design of test well 2.

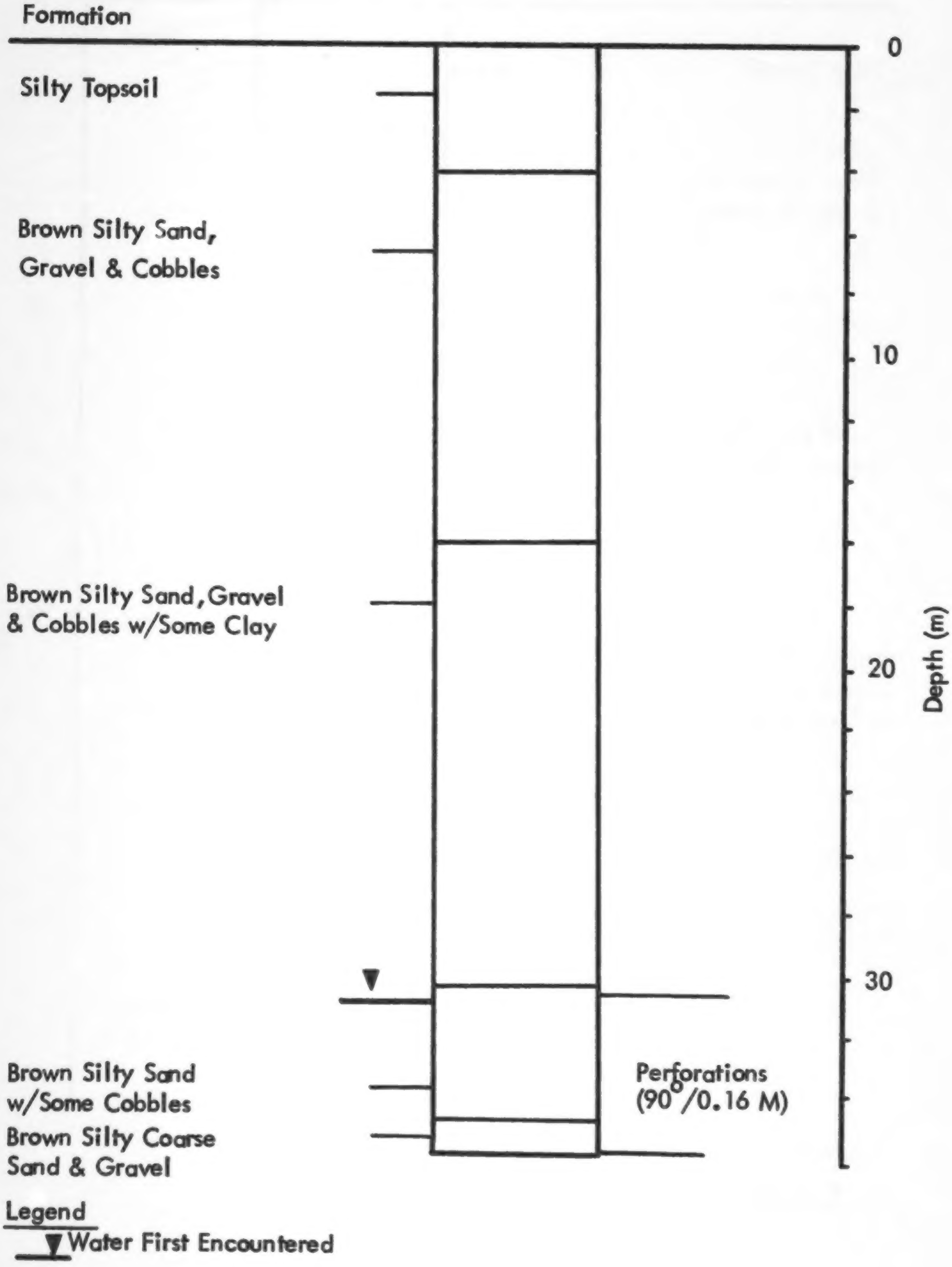

Formation
Silty Topsoil
Brown Silty Sand, Gravel & Cobbles
Brown Silty Sand, Gravel & Cobbles w/Some Clay
Brown Silty Sand w/Some Cobbles
Brown Silty Coarse Sand & Gravel
Perforations (90°/0.16 M)
0
10
20
30
Depth (m)
Legend
▼ Water First Encountered

Figure C-3. Well log and schematic design of test well 1.

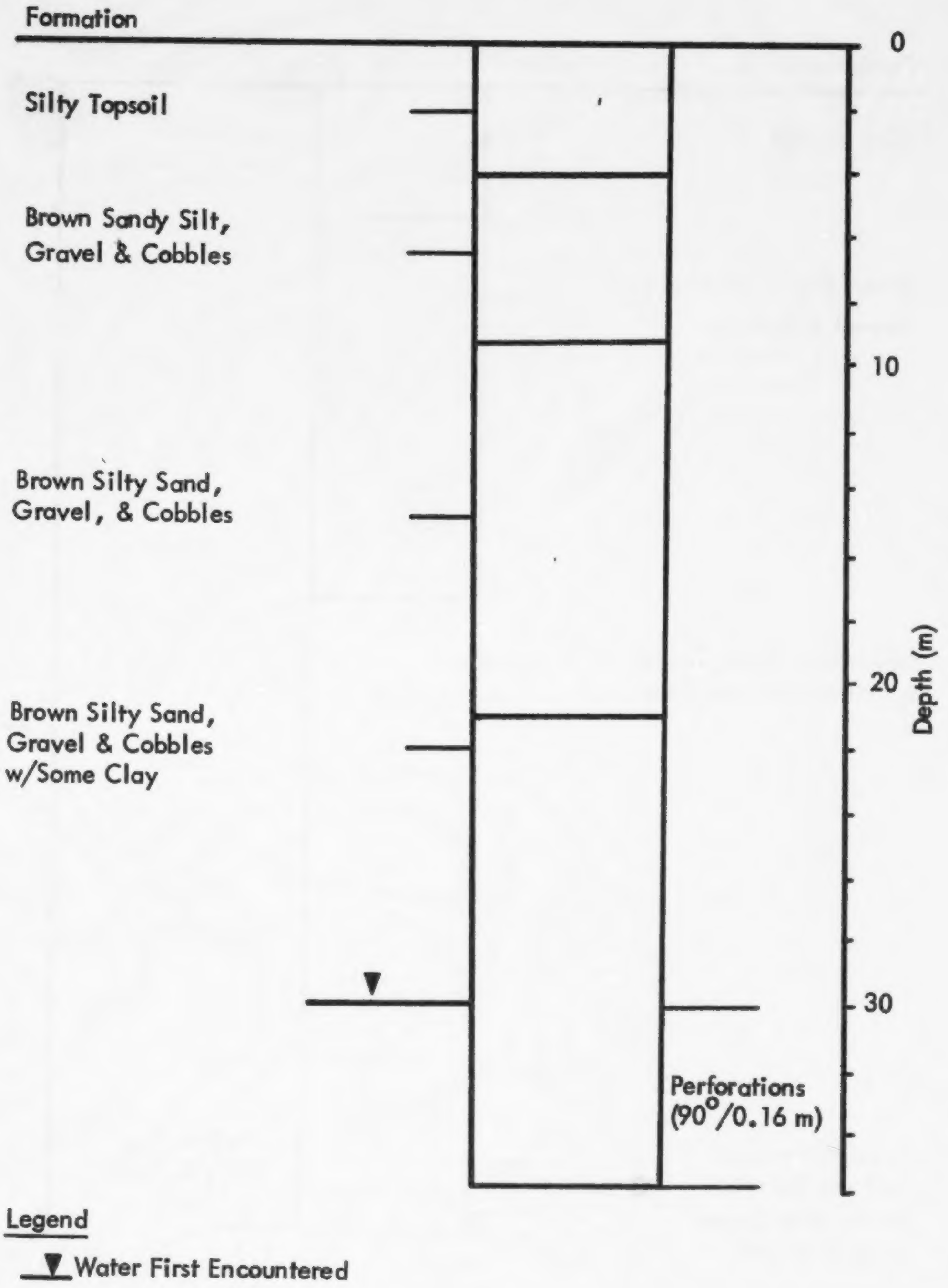

Formation
Silty Topsoil
Brown Sandy Silt,
Gravel & Cobbles
Brown Silty Sand,
Gravel, & Cobbles
Brown Silty Sand,
Gravel & Cobbles
w/Some Clay
Perforations
(90°/0.16 m)
0
10
20
30
Depth (m)
Legend
▼ Water First Encountered

Figure C-4. Well log and schematic design of test well 1.

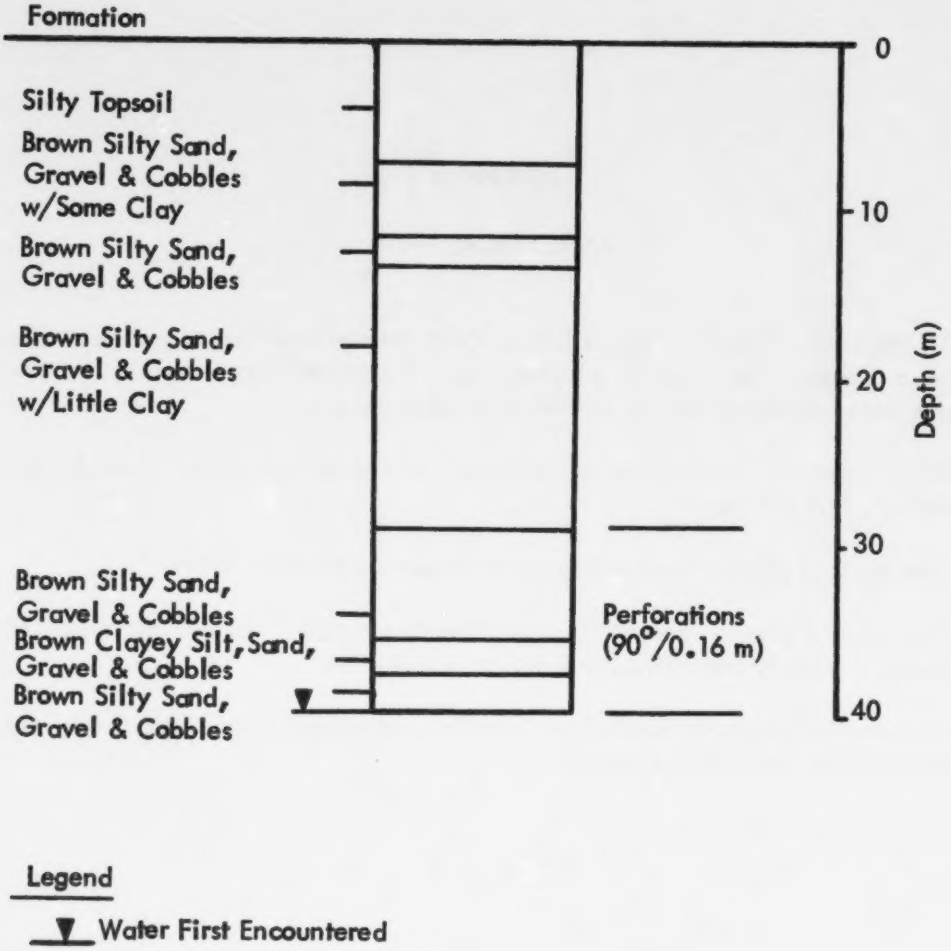

Formation
Silty Topsoil
Brown Silty Sand,
Gravel & Cobbles
w/Some Clay
Brown Silty Sand,
Gravel & Cobbles
Brown Silty Sand,
Gravel & Cobbles
w/Little Clay
Brown Silty Sand,
Gravel & Cobbles
Brown Clayey Silt, Sand,
Gravel & Cobbles
Brown Silty Sand,
Gravel & Cobbles
Perforations
(90°/0.16 m)
0
10
20
30
40
Depth (m)
Legend
▼ Water First Encountered

Figure C-5. Well log and schematic design of test well 1.

APPENDIX D

ANALYTICAL DATA

All the values listed in Figures D-1 to D-18 were printed out to two decimal places in order to simplify the computer programming. The actual reported values for the constituents were carried out to the following decimal places:

- Whole numbers: total and fecal coliform, total dissolved solids, chloride, sulfates, sodium, and calcium.
- One decimal place: total nitrogen, potassium, and molybdenum.
- Two decimal places: boron, fluoride, nitrate-nitrogen, barium, cadmium, chromium, copper, nickel, lead, zinc, arsenic, and selenium.

The other constituents (total organic carbon, phosphate, and magnesium) were reported to three significant figures.

TABLE D-1. ANALYTICAL RESULTS: TEST EFFLUENT

	* MPN/100 ml *		Constituent(mg/l)										
M.T.EFFLUENT	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
11/14/76	NES	NES	NES	0.55	431.00	2.18	NES	NES	NES	NES	52.00	13.30	253.00
12/ 1/76	1.02E+05	400.00	943.00	0.58	289.00	1.86	NES	NES	20.00	13.30	60.00	11.40	343.00
1/ 7/77	6.00E+07	0.00	NES	0.66	NES	NES	NES	NES	NES	NES	NES	20.00	395.00
2/ 7/77	NES	NES	NES	0.49	165.00	NES	NES	NES	30.00	NES	81.00	30.00	123.20
3/ 7/77	13600.00	0.00	794.00	0.60	232.00	NES	0.65	NES	NES	NES	65.50	16.50	181.00
4/ 1/77	24000.00	40.00	NES	0.27	403.00	1.30	NES	NES	66.00	10.00	73.00	19.00	198.00
4/ 7/77	24000.00	NES	NES	0.20	NES	0.44	NES	NES	NES	9.80	NES	23.00	230.00
4/14/77	24000.00	24000.00	1450.00	NES	270.00	NES	0.94	NES	61.00	8.00	44.00	20.00	230.00
5/ 1/77	24000.00	3500.00	NES	0.22	382.00	0.66	4.43	34.00	85.00	6.75	45.00	18.10	143.00
5/14/77	NES	NES	1360.00	0.19	392.00	0.62	0.10	NES	59.00	7.65	75.00	18.70	147.40
6/ 1/77	1.30E+06	1.30E+06	1595.00	0.13	436.00	1.53	NES	NES	94.00	4.90	64.00	11.50	144.10
6/14/77	3500.00	50.00	1430.00	0.46	379.00	1.19	6.00	30.00	83.00	10.80	48.00	24.00	149.00
7/ 1/77	600.00	60.00	NES	0.57	403.00	1.31	0.10	20.80	66.00	11.30	73.00	24.50	152.00
7/14/77	1.60E+06	2.80E+05	1080.00	0.30	431.00	1.49	2.36	NES	NES	7.74	55.00	16.10	260.00
8/ 1/77	2.40E+05	92000.00	NES	c	c	c	c	c	c	c	c	c	c
8/14/77	1.40E+05	94000.00	1158.00	0.42	447.00	1.79	0.40	21.90	87.00	8.97	50.00	15.30	272.00
9/14/77	17000.00	13.00	1102.00	0.37	467.00	NES	1.00	13.80	NES	8.50	NES	17.50	258.00
10/ 1/77	54000.00	11000.00	NES	0.78	441.00	1.76	1.80	24.80	65.00	8.30	81.00	18.50	225.00
11/ 7/77	2.20E+05	14000.00	914.00	0.36	433.00	1.19	0.30	28.60	58.00	8.00	69.00	16.50	230.00
11/21/77	3.50E+05	1.70E+05	862.00	0.57	387.00	1.26	0.15	24.80	26.00	8.40	78.00	15.90	288.00
12/ 7/77	50.00	0.00	640.00	c	c	c	c	c	c	c	c	c	c
12/21/77	2.40E+05	70.00	900.00	0.44	181.00	2.08	0.56	25.20	31.00	9.40	104.00	15.90	156.00
1/ 7/78	2.40E+05	92000.00	690.00	c	c	c	c	c	c	c	c	c	c
1/21/78	2.40E+05	9200.00	744.00	0.61	200.00	1.90	5.10	25.20	51.50	9.40	92.50	14.20	150.00

	Constituent(mg/l)											
M.T.EFFLUENT	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
11/14/76	NES	32.20	0.03	0.03	0.14	0.18	NES	0.14	0.20	0.08	0.01	0.01
12/ 1/76	NES	33.00	0.20	0.01	0.03	0.03	0.10	0.02	0.06	0.08	0.01	0.01
1/ 7/77	NES	34.80	0.01	0.00	0.10	0.09	NES	0.08	0.03	0.03	0.01	0.01
2/ 7/77	99.00	28.60	0.10	0.00	0.08	0.03	0.10	0.21	0.09	0.02	NES	NES
3/ 7/77	NES	32.40	0.31	0.05	0.04	0.02	NES	NES	0.02	0.01	NES	NES
4/ 1/77	62.00	27.30	0.30	0.00	0.05	0.08	0.10	0.09	0.20	NES	0.03	NES
4/ 7/77	62.00	84.00	NES	0.01	0.04	NES	0.10	NES	0.10	NES	NES	NES
4/14/77	68.00	76.00	0.10	0.02	0.03	0.21	0.10	NES	0.10	NES	0.01	0.01
4/21/77	NES	NES	NES	NES	NES	NES	NES	NES	NES	NES	NES	0.01
5/ 1/77	56.00	NES	0.10	0.01	NES	0.03	0.10	0.07	0.07	0.10	0.01	0.01
5/14/77	53.00	NES	0.10	0.01	0.04	0.07	NES	0.05	0.08	0.10	0.01	0.01
6/ 1/77	44.00	17.16	0.10	0.01	0.04	0.07	0.10	0.06	0.05	0.07	0.01	0.01
6/14/77	40.00	25.60	0.30	0.08	0.03	0.15	0.10	0.03	0.06	0.08	0.03	0.01
7/ 1/77	44.00	27.30	0.30	0.02	0.06	0.08	0.10	0.02	0.05	0.07	0.03	0.01
7/14/77	49.00	55.00	0.40	0.02	0.02	0.08	0.10	0.16	0.02	0.04	0.03	0.01
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	26.00	50.50	0.07	0.01	0.03	0.04	0.10	0.06	0.06	0.09	0.01	NES
9/14/77	32.00	33.00	0.20	0.02	0.02	0.05	0.10	0.02	0.12	0.06	0.01	0.01
10/ 1/77	36.00	53.00	0.08	0.01	0.01	0.09	0.10	0.02	0.13	0.08	0.01	0.01
11/ 7/77	32.00	35.00	0.15	0.01	0.01	0.06	0.10	0.03	0.02	0.09	0.01	0.01
11/21/77	44.00	48.00	0.07	0.01	0.02	0.11	0.10	0.07	0.02	0.06	0.01	0.01
12/ 7/77	c	c	c	c	c	c	c	c	c	c	c	c
12/21/77	24.00	64.00	0.03	0.02	0.04	0.10	0.10	0.04	0.08	0.05	0.01	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	24.00	37.00	0.19	0.01	0.01	0.13	0.10	0.03	0.02	0.06	0.01	0.01

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TABLE D-2. ANALYTICAL RESULTS: CONTROL IRRIGATION

	* MPN/100 ml *		Constituent(mg/l)										
M.C. IRRIGATION	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
1/ 1/77	NES	NES	570.00	NES	239.00	0.47	NES	NES	NES	NES	50.00	NES	249.00
2/14/77	NES	NES	810.00	NES	202.00	NES	3.56	NES	14.90	NES	65.00	NES	NES
3/14/77	0.00	0.00	626.00	0.15	182.00	0.95	5.10	NES	NES	NES	42.00	5.00	142.00
4/ 1/77	27.00	20.00	NES	NES	NES	NES	NES	NES	NES	NES	NES	NES	NES
4/ 7/77	50.00	NES	1050.00	0.10	NES	1.00	1.32	NES	NES	0.13	NES	9.00	170.00
4/14/77	230.00	230.00	1130.00	0.09	370.00	0.84	2.70	3.54	2.00	0.10	52.00	7.00	170.00
5/ 1/77	90.00	20.00	970.00	0.30	264.00	0.23	0.13	0.55	5.00	0.08	NES	7.00	124.30
5/14/77	NES	NES	998.00	0.22	230.00	0.21	1.17	NES	3.60	0.90	45.00	5.90	121.00
6/ 1/77	450.00	0.00	1190.00	0.18	NES	0.70	NES	NES	44.00	1.00	55.00	6.70	123.20
6/14/77	170.00	20.00	1090.00	0.14	277.00	0.63	4.30	4.30	14.00	1.32	48.00	8.40	125.00
7/ 1/77	100.00	0.00	NES	0.25	311.00	0.14	5.62	5.80	39.00	2.06	44.00	9.20	121.00
7/14/77	0.00	0.00	760.00	0.14	286.00	0.43	5.40	5.70	NES	0.16	33.00	5.20	NES
8/ 1/77	40.00	40.00	798.00	c	c	c	c	c	c	c	c	c	c
8/14/77	230.00	0.00	826.00	0.12	323.00	0.20	2.10	2.10	2.00	0.22	57.60	6.00	205.00
9/ 1/77	NES	NES	NES	c	c	c	c	c	c	c	c	c	c
9/14/77	100.00	0.00	854.00	0.18	317.00	0.51	0.90	1.00	8.00	0.13	64.00	6.40	186.00
10/ 1/77	0.00	0.00	NES	0.26	296.00	0.50	0.50	5.00	47.00	0.10	65.00	5.80	150.00
11/ 7/77	2600.00	50.00	392.00	0.27	164.00	0.20	3.00	3.10	19.50	0.10	72.00	5.00	98.00
11/21/77	2200.00	1100.00	526.00	0.30	137.00	0.46	6.00	7.10	3.50	0.12	67.00	5.40	111.00
12/ 7/77	1.60E+05	0.00	702.00	c	c	c	c	c	c	c	c	c	c
12/21/77	2400.00	0.00	820.00	0.16	239.00	0.59	1.30	2.30	53.00	0.10	42.00	5.70	171.00
1/21/78	35000.00	16000.00	620.00	0.16	229.00	0.76	0.90	1.90	22.50	0.90	62.50	5.30	130.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
1/ 1/77	51.50	18.20	NES	0.01	0.10	0.20	NES	0.18	0.01	0.01	NES	NES
2/14/77	NES	NES	NES	NES	NES	0.03	NES	0.08	NES	NES	NES	NES
3/14/77	NES	44.00	NES	0.04	0.03	0.03	NES	0.01	0.04	NES	NES	NES
4/ 7/77	57.00	68.00	NES	0.01	0.04	0.21	NES	0.09	0.10	NES	NES	NES
4/14/77	58.00	66.00	0.20	0.01	0.01	0.14	0.10	0.05	0.01	0.03	0.01	0.01
5/ 1/77	56.00	17.05	0.10	0.01	0.02	0.01	0.10	0.06	0.15	0.03	0.01	0.01
5/14/77	44.00	15.35	0.10	0.01	0.02	0.05	NES	0.06	0.06	0.09	0.01	0.01
6/ 1/77	42.00	14.96	0.10	0.01	0.00	0.06	0.10	0.10	0.06	0.03	0.01	0.01
6/14/77	44.00	21.60	0.20	0.02	0.02	0.18	0.10	0.03	0.02	0.02	0.02	0.01
7/ 1/77	33.00	26.00	0.10	0.03	0.03	0.03	0.10	0.05	0.06	0.07	0.03	0.01
7/14/77	49.00	62.10	0.20	0.01	0.04	0.19	0.10	0.02	0.02	0.01	0.06	0.01
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	27.00	46.60	0.20	0.01	0.06	0.10	0.10	0.04	0.04	0.02	0.01	NES
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	48.00	32.00	0.08	0.02	0.02	0.04	0.10	0.02	0.02	0.02	0.01	0.01
10/ 1/77	36.00	46.80	0.08	0.02	0.02	0.07	0.10	0.01	0.03	0.02	NES	NES
10/ 7/77	NES	NES	NES	NES	NES	NES	NES	NES	NES	NES	0.01	0.01
11/ 7/77	36.00	42.00	0.18	0.01	0.01	0.03	0.10	0.02	0.02	0.02	0.01	0.01
11/21/77	40.00	57.00	0.13	0.01	0.02	0.03	0.10	0.05	0.06	0.02	0.01	0.01
12/ 7/77	c	c	c	c	c	c	c	c	c	c	c	c
12/21/77	30.00	32.00	0.05	0.01	0.04	0.04	0.10	0.02	0.07	0.02	0.01	0.01
1/21/78	29.00	26.00	0.10	0.01	0.01	0.03	0.10	0.03	0.02	0.07	0.01	0.01

TABLE D-3. ANALYTICAL RESULTS: TEST LYSIMETER, 50 CM

	* MPN/100 ml *		Constituent(mg/l)										
MTL-50	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
4/ 1/77	0.00	0.00	NES	0.14	311.00	0.80	78.20	NES	NES	10.80	95.00	12.10	131.00
10/21/77	0.00	0.00	1140.00	NES	NES	NES	NES	NES	NES	NES	NES	13.20	150.00
11/14/77	0.00	0.00	1100.00	c	c	c	c	c	c	c	c	c	c
11/21/77	0.00	0.00	1600.00	0.40	334.00	1.00	32.50	36.20	7.00	2.40	62.00	17.50	240.00
12/21/77	0.00	0.00	1860.00	0.39	468.00	0.59	57.00	58.00	7.00	3.10	100.00	19.60	300.00
1/ 7/78	0.00	0.00	1984.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	1361.00	0.41	406.00	1.00	69.80	70.00	11.00	3.60	185.00	12.80	290.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
4/ 1/77	130.00	49.17	0.10	0.01	0.03	0.06	0.10	0.09	0.08	0.17	0.01	0.01
10/21/77	25.00	50.00	0.24	0.01	0.03	0.03	0.10	0.02	0.02	0.15	NES	NES
11/14/77	c	c	c	c	c	c	c	c	c	c	c	c
11/21/77	55.00	41.00	0.33	0.01	0.03	0.09	0.10	0.09	0.05	0.11	0.01	0.01
12/21/77	66.00	59.00	0.19	0.01	0.02	0.07	0.10	0.02	0.08	0.20	0.01	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	78.00	56.00	0.23	0.01	0.01	0.05	0.10	0.03	0.11	0.30	0.01	0.01

TABLE D-4. ANALYTICAL RESULTS: TEST LYSIMETER, 100 CM

	* MPN/100 ml *		Constitunnt(mg/l)										
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
2/ 1/77	0.00	0.00	NES	NES	363.90	0.63	NES	NES	NES	NES	NES	25.50	263.00
3/14/77	NES	NES	1210.00	0.35	272.00	1.80	72.00	NES	NES	4.50	96.00	11.60	295.00
4/ 1/77	0.00	0.00	NES	0.27	266.00	0.89	71.00	72.10	39.00	9.60	102.00	9.90	129.00
7/ 7/77	80.00	80.00	NES	NES	NES	NES	NES	NES	NES	NES	59.00	NES	NES
11/14/77	0.00	0.00	674.00	c	c	c	c	c	c	c	c	c	c
11/21/77	0.00	0.00	1284.00	1.18	229.00	1.25	29.50	31.60	2.50	1.40	415.00	23.70	576.00
12/ 7/77	0.00	0.00	1670.00	c	c	c	c	c	c	c	c	c	c
12/21/77	0.00	0.00	1470.00	0.24	334.00	1.15	35.00	36.00	11.00	2.70	173.00	11.60	256.00
1/ 7/78	0.00	0.00	1796.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	1291.00	0.35	431.00	0.90	45.00	46.00	12.00	3.00	213.00	11.00	315.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
2/ 1/77	199.50	27.00	NES	NES	0.08	0.04	NES	0.19	0.06	0.09	NES	NES
3/14/77	14.70	59.00	0.04	0.04	0.06	0.05	NES	0.10	0.04	0.16	NES	NES
4/ 1/77	63.00	23.21	0.10	0.01	0.05	0.07	NES	0.08	0.06	0.18	0.02	0.01
11/14/77	c	c	c	c	c	c	c	c	c	c	c	c
11/21/77	200.00	NES	0.27	0.02	0.05	NES	0.10	0.21	0.05	0.20	0.01	0.01
12/ 7/77	c	c	c	c	c	c	c	c	c	c	c	c
12/21/77	55.00	43.00	0.23	0.01	0.03	0.06	0.10	0.02	0.06	0.12	0.01	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	71.00	45.00	0.18	0.01	0.01	0.07	0.10	0.03	0.08	0.23	0.01	0.01

TABLE D-5. ANALYTICAL RESULTS: CONTROL LYSIMETER, 50 cm

	* MPN/100 ml *		Constituent(mg/l)										
MCL-50	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
8/14/77	20.00	0.00	1242.00	0.45	486.00	NES	18.00	NES	NES	1.00	144.00	NES	285.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
8/14/77	NES	NES	NES	0.01	0.03	NES	NES	0.09	0.12	0.32	0.01	0.01

TABLE D-6. ANALYTICAL RESULTS: CONTROL LYSIMETER, 100 cm

	* MPN/100 ml *		Constituent(mg/l)										
MCL-100	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
4/ 1/77	NES	NES	NES	0.10	NES	NES	NES	NES	NES	5.40	NES	NES	NES
7/ 7/77	80.00	50.00	NES	NES	357.00	1.10	NES	NES	NES	NES	100.00	23.00	174.00
8/14/77	40.00	0.00	866.00	0.33	350.00	1.02	16.50	19.30	NES	1.76	69.00	8.20	246.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
4/ 1/77	NES	51.26	NES	0.01	NES	NES	0.10	NES	0.06	0.31	NES	NES
7/ 7/77	20.00	63.80	0.10	NES	0.01	0.30	0.10	NES	0.12	0.35	NES	NES
8/14/77	26.00	68.20	0.25	0.01	0.08	0.01	0.10	0.31	NES	0.45	0.01	0.01

TABLE B-7. ANALYTICAL RESULTS: TEST WELL, UPSTREAM #1, TOP

	* MPN/100 ml *						Constituent(mg/l)						
MTm-1-T	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
4/ 1/77	0.00	0.00	NES	NES	206.00	NES	NES	NES	NES	NES	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	205.00	NES	1.21	NES	NES	0.47	NES	NES	NES
5/14/77	NES	NES	NES	c	c	c	1.32	c	c	0.37	c	c	c
6/ 7/77	0.00	0.00	738.00	0.38	233.00	0.21	5.20	NES	17.00	2.10	63.00	7.70	128.00
6/14/77	0.00	0.00	810.00	c	225.00	c	c	c	c	NES	c	c	c
7/ 7/77	16000.00	0.00	740.00	0.30	286.00	0.41	3.00	2.30	26.00	0.86	66.00	11.30	121.00
8/ 1/77	790.00	0.00	662.00	c	c	c	c	c	c	c	c	c	c
8/14/77	1000.00	0.00	756.00	0.54	277.00	NES	14.00	15.90	8.50	NES	47.00	NES	200.00
9/ 1/77	9400.00	20.00	582.00	c	c	c	c	c	c	c	c	c	c
9/14/77	20.00	0.00	736.00	0.25	224.00	0.68	7.00	7.70	7.50	0.80	72.00	6.00	154.00
10/ 1/77	20.00	0.00	858.00	0.38	256.00	1.38	7.70	8.20	NES	NES	NES	8.70	150.00
10/21/77	50.00	0.00	862.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	0.00	0.00	NES	0.23	248.00	0.14	5.00	5.90	5.40	0.52	NES	6.40	178.00
11/21/77	0.00	0.00	722.00	0.28	207.00	0.25	9.90	NES	22.50	1.16	NES	6.90	180.00
12/21/77	0.00	0.00	608.00	0.26	205.00	0.28	7.50	8.50	52.00	1.20	86.00	6.00	162.00
1/ 7/78	0.00	0.00	628.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	760.00	0.26	233.00	0.10	14.00	15.00	12.00	1.60	62.00	7.40	150.00

					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
4/ 1/77	NES	NES	NES	0.01	NES	NES	NES	0.21	NES	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	NES	NES	0.10	NES	NES	NES	NES	NES
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	36.00	16.83	0.10	0.01	0.01	0.07	0.10	0.03	0.21	0.11	0.01	0.01
6/14/77	c	c	c	c	c	c	c	c	c	c	c	c
7/ 7/77	35.00	21.70	0.20	0.02	0.02	0.15	0.10	0.02	0.24	0.20	0.01	NES
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	40.00	NES	NES	0.01	0.06	0.23	0.10	NES	0.23	NES	0.03	0.01
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	26.00	29.00	0.05	0.02	0.03	0.02	0.30	0.02	0.03	0.06	0.02	0.01
10/ 1/77	32.40	61.00	0.11	0.02	0.02	0.03	0.10	0.01	0.05	0.11	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	32.00	55.00	0.20	0.01	0.01	0.03	0.10	0.03	0.02	0.33	0.02	0.01
11/21/77	24.00	39.00	0.20	0.01	0.01	0.09	0.10	0.08	0.06	NES	0.03	NES
12/21/77	24.00	38.00	0.06	0.01	0.03	0.04	0.10	0.04	0.03	0.38	0.01	NES
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	28.00	30.00	0.28	0.01	0.01	0.04	0.10	0.02	0.80	0.05	0.02	0.01

TABLE D-8. ANALYTICAL RESULTS: CONTROL WELL, ON-SITE #1, TOP

	* MPN/100 ml *		Constituent(mg/l)										
MCW-1-T	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
4/ 1/77	20.00	0.00	NES	NES	269.00	NES	NES	NES	NES	NES	NES	NES	NES
4/14/77	NES	NES	NES	NES	225.00	NES	NES	NES	NES	NES	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	251.00	NES	1.55	NES	NES	3.80	NES	NES	NES
5/14/77	NES	NES	NES	c	c	c	1.35	c	c	0.29	c	c	c
6/ 7/77	0.00	0.00	606.00	0.59	265.00	0.10	4.70	4.80	19.00	2.80	46.00	9.90	130.00
6/14/77	0.00	0.00	970.00	c	260.00	c	c	c	c	NES	c	c	c
7/ 7/77	110.00	0.00	910.00	0.57	275.00	0.36	NES	NES	23.00	1.62	93.00	10.00	128.00
8/ 1/77	NES	NES	936.00	c	c	c	c	c	c	c	c	c	c
8/14/77	0.00	0.00	846.00	0.37	370.00	NES	8.50	10.80	24.00	NES	48.20	NES	220.00
9/ 1/77	0.00	0.00	867.00	c	c	c	c	c	c	c	c	c	c
9/14/77	0.00	0.00	966.00	0.48	269.00	0.68	5.60	5.60	23.00	0.53	57.00	8.60	173.00
9/21/77	490.00	0.00	792.00	c	c	c	c	c	c	c	c	c	c
10/ 1/77	20.00	0.00	1002.00	0.30	312.00	0.95	5.10	6.20	78.00	0.43	NES	8.90	150.00
10/21/77	0.00	0.00	1170.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	NES	NES	1134.00	0.38	368.00	0.40	4.20	4.30	15.60	0.50	NES	9.30	200.00
11/21/77	0.00	0.00	1142.00	0.45	333.00	0.70	2.10	3.10	38.50	0.10	78.00	10.10	231.00
12/21/77	20.00	0.00	1630.00	0.53	324.00	0.35	2.50	3.50	46.00	4.80	70.00	9.60	189.00
1/ 7/78	0.00	0.00	970.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	1044.00	0.53	336.00	0.10	9.00	10.00	8.50	0.10	65.00	9.20	175.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
4/ 1/77	98.00	NES	NES	0.01	NES	NES	NES	0.09	0.80	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	NES	NES	0.10	NES	NES	NES	NES	NES
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	75.00	28.38	0.20	0.01	0.03	0.08	0.10	0.10	0.34	0.42	0.02	0.01
6/14/77	c	c	c	c	c	c	c	c	c	c	c	c
7/ 7/77	63.00	37.80	0.10	0.02	0.07	0.10	0.10	0.06	0.65	0.19	0.03	0.01
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	NES	NES	NES	0.01	0.08	NES	0.10	NES	NES	NES	0.01	0.01
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	55.00	61.00	0.17	0.02	0.02	0.02	0.10	0.02	0.09	0.16	0.01	0.01
9/21/77	c	c	c	c	c	c	c	c	c	c	c	c
10/ 1/77	46.00	102.00	0.09	0.02	0.02	0.03	0.10	0.02	0.06	0.15	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	73.00	104.00	0.26	0.01	0.01	0.03	0.10	0.05	0.05	0.51	0.02	0.01
11/21/77	59.00	94.00	0.39	0.01	0.03	0.02	0.10	0.03	0.10	0.02	0.01	0.01
12/21/77	45.00	85.00	0.09	0.01	0.03	0.01	0.10	0.03	0.06	0.21	0.02	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	57.00	71.00	0.28	0.01	0.01	0.05	0.10	0.03	0.70	0.80	0.01	0.01

TABLE D-9. ANALYTICAL RESULTS: TEST WELL, UPSTREAM #1, BOTTOM

	* MPN/100 ml *			Constituent(mg/l)									
MTW-1-B	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
5/14/77	NES	NES	NES	c	c	c	1.39	c	c	0.40	c	c	c
6/ 7/77	0.00	0.00	732.00	0.36	234.00	0.63	NES	NES	22.00	2.90	76.00	8.20	128.00
6/14/77	0.00	0.00	800.00	c	226 00	c	c	c	c	1.87	c	c	c
7/ 7/77	20.00	0.00	740.00	0.25	406 00	0.08	3.00	3.30	40.00	NES	62 00	11.20	119.00
8/ 1/77	1100.00	20.00	636.00	c	c	c	c	c	c	c	c	c	c
8/14/77	5400.00	20.00	764.00	0.29	228.00	NES	8.00	9 90	34.00	NES	51 00	13.10	195.00
9/ 1/77	4600.00	0.00	662.00	c	c	c	c	c	c	c	c	c	c
9/14/77	NES	NES	766.00	0.32	238.00	0.72	7.50	7.60	7.50	0.78	62.00	6.10	158.00
10/ 1/77	170.00	0.00	792.00	0.30	258.00	NES	5.90	6.40	69.00	NES	NES	8.30	150.00
10/21/77	0.00	0.00	924.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	0.00	0.00	NES	0.20	246.00	0.42	4.40	4.80	15.00	0.40	NES	6.20	176.00
11/21/77	50.00	0.00	732.00	0.25	207.00	0.25	4.80	5.80	2.00	0.90	117.00	7.00	183.00
12/21/77	20.00	0.00	566.00	0.33	201.00	0.10	9.40	10.40	39.00	1.20	75.00	8.90	162.00
1/ 7/78	0.00	0.00	602.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	822.00	0.34	223.00	0.15	7.70	8.70	53.00	1.00	60.00	6.80	153.00

					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	39.00	19.25	0.10	0.01	0.03	0.08	0.10	0.08	0.20	0.21	0.01	NES
6/14/77	c	c	c	c	c	c	c	c	c	c	c	c
7/ 7/77	32.00	22.20	0.30	0.02	0.01	0.15	0.10	0.05	0.25	0.19	0.02	0.01
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	41.00	NES	NES	0.01	0.11	0.19	0.10	NES	0.28	NES	0.10	0.01
9/ 1/77	[illegible]	c	c	c	c	c	c	c	c	c	c	c
9/14/77	27.00	30.00	0.14	0.02	0.04	0.02	0.20	0.02	0.07	0.07	0.02	0.01
10/ 1/77	31.80	59.70	0.09	0.02	0.02	0.03	0.10	0.01	0.06	0.05	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	32.00	54.00	0.17	0.01	0.01	0.03	0.10	0.03	0.03	0.24	0.03	0.01
11/21/77	24.00	38.00	0.17	0.01	0.03	0.08	0.10	0.03	0.07	0.69	0.02	0.01
12/21/77	20.00	55.00	0.07	0.01	0.02	0.02	0.10	0.11	0.06	0.20	0.01	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	30.00	40.00	0.20	0.01	0.01	0.09	0.10	0.03	NES	0.87	0.02	0.01

TABLE D-10. ANALYTICAL RESULTS: CONTROL WELL, ON-SITE #1, BOTTOM

	* MPN/100 ml *		Constituent(mg/l)										
KCa-1-B	TC	FC	TDS	B	Cl	F	NO3	TH	TOC	PO4	SO4	K	Na
5/14/77	NES	NES	NES	c	c	c	c	c	c	0.29	c	c	c
6/ 7/77	0.00	0.00	868.00	0.50	273.00	0.10	4.10	5.60	15.00	NES	91.00	12.00	130.00
6/14/77	0.00	0.00	990.00	c	252.00	c	c	c	c	NES	c	c	c
7/ 7/77	140.00	0.00	970.00	0.58	277.00	0.98	NES	NES	NES	NES	55.00	9.70	123.00
8/ 1/77	40.00	0.00	944.00	c	c	c	c	c	c	c	c	c	c
8/14/77	270.00	80.00	1342.00	0.70	359.00	0.83	NES	15.50	26.00	NES	88.00	NES	NES
9/ 1/77	40.00	0.00	904.00	c	c	c	c	c	c	c	c	c	c
9/14/77	NES	NES	946.00	0.45	292.00	0.76	5.50	5.50	10.00	0.43	56.00	8.40	173.00
9/21/77	24000.00	0.00	782.00	c	c	c	c	c	c	c	c	c	c
10/ 1/77	0.00	0.00	1006.00	0.47	309.00	0.95	4.70	5.50	79.00	0.46	NES	8.70	151.00
10/21/77	0.00	0.00	1224.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	NES	NES	1122.00	0.49	366.00	0.30	5.00	5.10	20.90	0.20	NES	9.30	208.00
11/21/77	20.00	0.00	1002.00	0.40	334.00	0.51	3.30	4.30	0.50	0.60	NES	10.00	189.00
12/21/77	0.00	0.00	1870.00	0.37	285.00	0.10	4.10	5.10	21.00	1.64	54.00	8.90	171.00
1/ 7/78	0.00	0.00	946.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	905.00	0.47	327.00	0.15	5.40	6.40	1.50	1.04	65.00	8.90	175.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	79.00	29.92	0.30	0.01	0.07	0.10	0.10	0.12	0.37	0.02	0.02	0.01
6/14/77	c	c	c	c	c	c	c	c	c	c	c	c
7/ 7/77	63.00	40.40	0.20	0.02	0.06	0.11	0.10	0.09	NES	0.31	0.03	0.01
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	NES	92.40	NES	0.01	0.05	NES	0.20	NES	0.29	NES	0.02	0.01
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	55.00	62.30	0.15	0.02.	0.03	0.03	0.10	0.01	0.11	0.20	0.01	0.01
9/21/77	c	c	c	c	c	c	c	c	c	c	c	c
10/ 1/77	46.50	101.00	0.10	0.02	0.02	0.03	0.10	0.01	0.05	0.07	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	73.00	104.00	0.27	0.01	0.01	0.06	0.10	0.06	0.02	0.47	0.02	0.01
11/21/77	67.00	86.00	0.40	0.01	0.02	0.05	0.10	0.06	0.04	0.03	0.01	0.01
12/21/77	41.00	75.00	0.07	0.01	0.04	0.02	0.10	0.05	0.05	0.31	0.02	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	57.00	71.00	0.27	0.01	0.01	0.06	0.10	0.03	NES	0.65	0.02	0.01

TABLE D-11. ANALYTICAL RESULTS: TEST WELL, UPSTREAM #2, TOP

	* MPN/100 ml *		Constituent(mg/l)										
MTW-2-T	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
4/ 1/77	0.00	0.00	NES	NES	242.00	NES	NES	NES	NES	NES	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	230.00	NES	NES	NES	NES	0.23	NES	NES	NES
5/14/77	NES	NES	NES	c	c	c	NES	c	c	0.29	c	c	c
6/ 7/77	0.00	0.00	788.00	0.43	257.00	0.59	1.60	3.30	20.00	NES	96.00	7.30	131.00
6/14/77	0.00	0.00	680.00	NES	170.00	NES	NES	NES	NES	NES	NES	NES	NES
8/ 1/77	0.00	0.00	636.00	c	c	c	c	c	c	c	c	c	c
8/14/77	30.00	0.00	688.00	0.38	238.00	1.14	6.50	7.80	13.00	NES	53.00	10.30	211.00
9/ 1/77	220.00	0.00	700.00	c	c	c	c	c	c	c	c	c	c
9/14/77	0.00	0.00	792.00	0.17	222.00	0.54	4.30	4.30	15.00	0.35	58.00	6.00	147.00
10/ 1/77	170.00	0.00	736.00	0.36	228.00	NES	4.50	5.00	84.00	NES	NES	7.30	132.00
10/21/77	340.00	0.00	896.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	NES	NES	NES	0.15	242.00	0.20	5.50	6.70	13.00	0.52	NES	6.60	170.00
11/21/77	0.00	0.00	686.00	0.26	176.00	0.25	2.40	8.00	1.50	0.84	124.00	7.40	156.00
12/21/77	0.00	0.00	458.00	0.33	224.00	0.28	6.90	7.90	54.00	NES	100.00	6.60	159.00
1/ 7/78	0.00	0.00	648.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	638.00	0.33	237.00	0.70	7.60	8.60	1.00	1.40	62.00	6.20	158.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
4/ 1/77	78.00	NES	NES	0.01	NES	NES	NES	0.04	NES	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	NES	NES	0.10	NES	NES	NES	NES	NES
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	51.00	NES	0.20	0.01	0.01	0.05	0.10	0.03	0.15	0.11	0.01	0.01
6/14/77	NES	NES	NES	NES	NES	0.21	NES	0.03	NES	NES	NES	NES
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	26.00	62.70	NES	0.01	0.20	0.15	0.10	NES	0.15	0.59	0.06	0.01
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	26.00	30.00	0.09	0.02	0.03	0.02	0.10	0.02	0.10	0.06	0.02	0.01
10/ 1/77	27.50	55.80	0.07	0.02	0.02	0.03	0.10	0.01	0.03	0.15	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	35.00	49.00	0.22	0.01	0.01	0.03	0.10	0.03	0.02	0.22	0.02	0.01
11/21/77	21.00	33.00	0.39	0.01	0.01	0.07	0.10	0.08	0.09	0.53	0.03	0.01
12/21/77	21.00	42.00	0.07	0.01	0.03	0.04	0.10	0.02	0.07	0.18	0.01	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	30.00	37.00	0.44	0.01	0.01	0.05	0.10	0.04	0.39	0.76	0.02	0.01

TABLE D-12. ANALYTICAL RESULTS: CONTROL WELL, ON-SITE #2, TOP

	* MPN/100 ml *		Constituent(mg/l)										
MCW-2-T	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
4/ 1/77	20.00	0.00	NES	NES	268.00	NES	NES	NES	NES	NES	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	369.00	NES	1.32	NES	NES	0.09	NES	NES	NES
5/14/77	NES	NES	NES	c	c	c	1.37	c	c	0.07	c	c	c
6/ 7/77	0.00	0.00	1346.00	0.50	443.00	0.70	4.10	5.60	83.00	2.50	120.00	10.80	165.00
6/14/77	0.00	0.00	1650.00	c	487.00	c	c	c	c	NES	c	c	c
7/ 7/77	0.00	0.00	1690.00	0.42	352.00	0.24	NES	NES	NES	NES	136.00	18.20	398.00
8/ 1/77	20.00	0.00	1316.00	c	c	c	c	c	c	c	c	c	c
8/14/77	20.00	0.00	1320.00	0.54	412.00	0.48	4.50	5.10	3.00	NES	91.00	14.20	370.00
9/ 1/77	330.00	0.00	1268.00	c	c	c	c	c	c	c	c	c	c
9/14/77	110.00	0.00	1362.00	0.45	451.00	0.76	8.60	8.70	10.00	0.20	112.00	7.60	293.00
9/21/77	490.00	0.00	1940.00	c	c	c	c	c	c	c	c	c	c
10/ 1/77	80.00	0.00	1746.00	0.53	631.00	1.15	20.70	21.20	88.00	0.35	200.00	10.70	320.00
10/21/77	20.00	0.00	1340.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	80.00	0.00	1200.00	0.46	402.00	0.30	2.10	2.30	37.00	0.15	NES	8.60	300.00
11/21/77	0.00	0.00	748.00	0.27	270.00	0.75	2.60	3.60	0.50	0.16	83.00	6.00	219.00
12/21/77	0.00	0.00	1500.00	0.26	337.00	0.59	5.50	6.50	47.00	0.10	91.00	7.60	243.00
1/ 7/78	50.00	0.00	1186.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	1090.00	0.28	351.00	1.13	6.30	7.30	3.00	1.10	101.00	7.10	285.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
4/ 1/77	73.00	NES	NES	0.00	NES	NES	NES	0.14	0.20	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	NES	NES	0.10	NES	NES	NES	NES	NES
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	84.00	34.98	0.10	0.01	0.08	0.09	0.10	0.09	0.15	0.08	0.02	0.01
6/14/77	c	c	c	c	c	c	c	c	c	c	c	c
7/ 7/77	56.00	65.80	NES	0.03	0.05	0.18	0.10	0.09	0.34	0.15	0.02	0.01
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	NES	NES	NES	0.01	0.03	0.01	0.20	NES	0.17	0.31	0.01	0.01
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	62.00	68.60	0.09	0.02	0.02	0.03	0.10	0.02	0.12	0.03	0.01	0.01
9/21/77	c	c	c	c	c	c	c	c	c	c	c	c
10/ 1/77	65.40	169.00	0.13	0.02	0.02	0.06	0.10	0.02	0.06	0.01	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	74.00	114.00	0.25	0.01	0.01	0.06	0.10	0.02	0.06	0.27	0.01	0.01
11/21/77	23.00	67.00	0.29	0.01	0.02	0.03	0.10	0.03	0.05	0.03	0.01	0.01
12/21/77	15.00	105.00	0.08	0.01	0.03	0.02	0.10	0.03	0.06	0.18	0.02	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	71.00	81.00	0.26	0.01	0.01	0.05	0.10	0.03	0.26	0.53	0.01	0.01

TABLE D-13. ANALYTICAL RESULTS: TEST WELL, UPSTREAM #2, BOTTOM

MTW-2-B	* MPN/100 ml *		Constituent(mg/l)										
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
5/14/77	NES	NES	NES	c	c	c	0.22	c	c	0.28	c	c	c
6/ 7/77	0.00	0.00	760.00	0.42	261.00	0.20	4.00	4.80	37.00	NES	61.00	7.60	123.00
6/14/77	0.00	0.00	820.00	NES	245.00	NES	NES	NES	8.10	NES	NES	2.80	137.00
8/ 1/77	220.00	20.00	746.00	c	c	c	c	c	c	c	c	c	c
8/14/77	40.00	0.00	708.00	0.45	237.00	1.20	8.50	9.30	22.00	NES	51.00	10.40	205.00
9/ 1/77	230.00	0.00	674.00	c	c	c	c	c	c	c	c	c	c
9/14/77	NES	NES	762.00	0.32	209.00	0.68	3.70	3.70	12.00	0.33	60.00	5.80	145.00
10/ 1/77	170.00	0.00	730.00	0.32	227.00	1.25	4.40	4.90	53.00	NES	NES	7.10	133.00
10/21/77	9200.00	20.00	900.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	50.00	0.00	NES	0.36	240.00	0.24	5.50	6.30	13.00	0.46	NES	6.70	170.00
11/21/77	0.00	0.00	764.00	0.31	203.00	0.25	3.10	4.10	1.00	0.84	86.00	6.80	180.00
12/21/77	0.00	0.00	700.00	0.26	211.00	0.28	6.90	7.90	46.00	0.10	74.00	6.00	156.00
1/ 7/78	0.00	0.00	604.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	NES	0.25	235.00	0.95	1.00	1.50	0.50	1.70	60.00	7.70	155.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	46.00	20.79	0.10	0.01	0.01	0.07	0.10	0.06	0.20	0.10	0.01	0.01
6/14/77	NES	30.20	NES	NES	NES	0.12	NES	0.06	0.20	0.08	NES	NES
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	26.00	77.00	NES	0.01	0.08	0.17	0.10	NES	0.26	NES	0.04	0.01
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	28.00	30.20	0.13	0.02	0.02	0.02	0.20	0.02	0.03	0.07	0.01	0.01
10/ 1/77	27.30	54.50	0.06	0.02	0.02	0.02	0.10	0.01	0.11	0.09	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	30.00	49.00	0.21	0.01	0.01	0.03	0.10	0.03	0.02	0.17	0.02	0.01
11/21/77	23.00	37.00	0.31	0.02	0.02	0.05	0.10	0.03	0.06	0.29	0.03	0.01
12/21/77	20.00	42.00	0.07	0.01	0.02	0.02	0.10	0.01	0.10	0.09	0.02	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	31.00	38.00	0.27	0.01	0.01	0.05	0.10	0.03	0.84	0.65	0.01	0.01

TABLE D-14. ANALYTICAL RESULTS: CONTROL WELL, ON-SITE #2, BOTTOM

	* MPN/100 ml *		Constituent(mg/l)										
MCe-2-B	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
5/14/77	NES	NES	NES	c	c	c	1.32	c	c	0.50	c	c	c
6/ 7/77	0.00	0.00	1370.00	0.47	430.00	0.73	NES	NES	21.00	0.90	106.00	12.00	164.00
6/14/77	0.00	0.00	1590.00	c	491.00	c	c	c	c	NES	c	c	c
7/ 7/77	110.00	0.00	1760.00	0.45	535.00	0.60	12.60	13.40	32.00	NES	135.00	18.40	176.00
8/ 1/77	340.00	50.00	1128.00	c	c	c	c	c	c	c	c	c	c
8/14/77	30.00	0.00	984.00	0.60	276.00	NES	10.50	12.70	10.00	NES	66.00	20.60	300.00
9/ 1/77	90.00	0.00	1266.00	c	c	c	c	c	c	c	c	c	c
9/14/77	NES	NES	1720.00	0.47	491.00	0.79	NES	NES	7.00	0.12	120.00	8.00	323.00
9/21/77	NES	NES	1504.00	c	c	c	c	c	c	c	c	c	c
10/ 1/77	0.00	0.00	1666.00	0.44	586.00	1.25	18.00	18.10	82.00	0.34	150.00	10.20	310.00
10/21/77	0.00	0.00	1332.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	0.00	0.00	1226.00	0.30	402.00	NES	2.10	2.30	32.50	0.10	NES	7.80	298.00
11/21/77	0.00	0.00	1120.00	0.26	341.00	0.51	9.30	10.30	0.50	0.10	107.00	7.60	267.00
12/21/77	0.00	0.00	1540.00	0.25	324.00	0.48	5.50	6.50	33.00	0.10	95.00	7.10	240.00
1/ 7/78	0.00	0.00	1102.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	1085.00	0.34	356.00	0.15	6.90	7.90	6.00	1.10	127.00	7.00	260.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	112.00	42.24	0.10	0.01	0.08	0.08	0.10	0.20	0.13	0.19	0.01	NES
6/14/77	c	c	c	c	c	c	c	c	c	c	c	c
7/ 7/77	100.00	62.30	0.20	0.02	0.02	0.30	0.10	0.11	NES	0.19	0.02	0.01
6/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	NES	96.60	NES	0.01	0.02	0.14	0.10	NES	NES	NES	0.02	0.01
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	80.00	116.50	0.07	0.02	0.02	0.02	0.10	0.02	0.06	0.04	0.01	0.01
9/21/77	c	c	c	c	c	c	c	c	c	c	c	c
10/ 1/77	59.90	162.00	0.07	0.01	0.01	0.03	0.10	0.02	0.02	0.01	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	74.00	112.00	0.21	0.01	0.01	0.03	0.10	0.04	0.05	0.23	0.01	0.01
11/21/77	78.00	90.00	0.36	0.01	0.03	0.05	0.10	0.07	0.07	0.30	0.01	0.01
12/21/77	32.00	100.00	0.07	0.02	0.04	0.02	0.10	0.02	0.03	0.11	0.01	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	71.00	78.00	0.21	0.01	0.01	0.03	0.10	0.03	0.30	0.34	0.01	0.01

TABLE D-15. ANALYTICAL RESULTS: TEST WELL, DOWNSTREAM #3, TOP

	* MPN/100 ml *				Constituent(mg/l)								
	TC	FC	TDS	[illegible]	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
4/ 1/77	NES	NES	NES	NES	330.00	NES	NES	NES	NES	NES	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	331.00	NES	3.07	NES	NES	0.10	NES	NES	NES
5/14/77	NES	NES	NES	c	c	c	3.10	c	c	0.35	c	c	c
6/ 7/77	0.00	0.00	1160.00	0.61	364.00	0.30	NES	NES	27.00	2.40	84.00	9.40	184.00
6/14/77	0.00	0.00	1240.00	c	347.00	c	c	c	c	NES	c	c	c
7/ 7/77	16000.00	1400.00	1200.00	0.64	235.00	0.23	NES	NES	35.00	5.78	85.00	14.00	146.00
8/ 1/77	170.00	0.00	1140.00	c	c	c	c	c	c	c	c	c	c
8/14/77	80.00	0.00	1084.00	0.67	350.00	0.32	26.50	27.80	24.00	4.75	62.00	NES	270.00
9/ 1/77	130.00	0.00	1006.00	c	c	c	c	c	c	c	c	c	c
9/14/77	50.00	0.00	1184.00	0.62	333.00	0.72	18.20	18.20	6.50	0.26	58.00	6.50	222.00
10/ 1/77	130.00	0.00	1384.00	0.58	356.00	1.25	8.90	9.00	76.00	NES	NES	8.10	202.00
10/21/77	0.00	0.00	1394.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	0.00	0.00	NES	0.52	395.00	0.20	2.30	2.50	15.40	0.36	NES	7.40	220.00
11/21/77	20.00	0.00	1198.00	0.42	251.00	0.51	13.00	14.00	0.50	0.28	89.00	8.00	270.00
12/21/77	20.00	0.00	1590.00	0.58	386.00	0.10	15.00	16.00	49.00	NES	118.00	8.70	252.00
1/ 7/78	0.00	0.00	522.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	628.00	0.79	401.00	0.15	18.00	19.00	1.50	1.30	92.00	9.60	285.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
4/ 1/77	NES	NES	NES	0.01	NES	NES	NES	0.12	NES	NES	NES	NES
5/ 7/77	NES	NES	NES	NES	NES	NES	0.10	NES	NES	NES	NES	NES
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	77.00	32.89	0.10	0.01	0.04	0.12	0.10	0.06	0.08	0.10	0.01	0.01
6/14/77	c	c	c	c	c	c	c	c	c	c	c	c
7/ 7/77	53.00	53.10	0.20	0.02	0.07	0.20	0.10	0.09	0.07	0.30	0.03	0.01
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	52.00	NES	0.64	0.01	0.02	0.09	0.10	NES	NES	NES	0.02	0.01
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	56.00	67.20	0.15	0.02	0.02	0.05	0.30	0.02	0.06	0.05	0.01	0.01
10/ 1/77	47.80	106.00	0.08	0.02	0.02	0.02	0.10	0.01	0.03	0.06	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	66.00	105.00	0.20	0.01	0.01	0.05	0.10	0.03	0.03	0.09	0.02	0.01
11/21/77	63.00	81.00	0.32	0.01	0.04	0.03	0.10	0.04	0.10	0.05	0.02	0.01
12/21/77	54.00	101.00	0.09	0.01	0.02	0.03	0.10	0.06	0.11	0.27	0.02	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	68.00	82.00	0.40	0.01	0.01	0.06	0.10	0.06	0.67	0.87	0.02	0.01

TABLE D-16. ANALYTICAL RESULTS: TEST WELL, DOWNSTREAM #3, BOTTOM

MTW-3-B	* MPN/100 ml *		Constituent(mg/l)										
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
5/14/77	NES	NES	NES	c	c	c	3.18	c	c	0.50	c	c	c
6/ 7/77	0.00	0.00	1206.00	0.49	389.00	0.60	NES	NES	19.00	3.00	77.00	10.10	149.00
6/14/77	0.00	0.00	1270.00	c	357.00	c	c	c	c	NES	c	c	c
7/ 7/77	130.00	20.00	1250.00	0.78	362.00	0.57	NES	NES	56.00	6.72	65.00	15.80	142.00
8/ 1/77	170.00	0.00	750.00	c	c	c	c	c	c	c	c	c	c
8/14/77	90.00	0.00	1074.00	0.63	280.00	2.52	16.50	16.80	19.00	6.31	58.00	34.20	220.00
9/ 1/77	330.00	0.00	912.00	c	c	c	c	c	c	c	c	c	c
9/14/77	NES	NES	1152.00	0.45	312.00	0.72	13.00	13.00	9.00	0.28	71.00	6.20	212.00
10/ 1/77	230.00	0.00	1192.00	0.56	357.00	NES	12.00	13.30	NES	NES	NES	8.20	202.00
10/21/77	0.00	0.00	1318.00	c	c	c	c	c	c	c	c	c	c
11/ 7/77	230.00	0.00	NES	0.57	395.00	0.20	1.70	1.90	27.50	0.20	NES	7.50	220.00
11/21/77	20.00	0.00	1296.00	0.68	359.00	0.51	5.50	8.80	36.50	0.10	93.00	7.80	270.00
12/21/77	20.00	0.00	1510.00	0.72	378.00	0.28	15.50	16.50	42.00	0.48	95.00	7.60	255.00
1/ 7/78	0.00	0.00	1222.00	c	c	c	c	c	c	c	c	c	c
1/21/78	0.00	0.00	1360.00	0.62	381.00	0.95	12.00	13.00	40.00	1.40	88.00	7.50	280.00

	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
5/14/77	c	c	c	c	c	c	c	c	c	c	c	c
6/ 7/77	96.00	43.12	0.10	0.01	0.06	0.07	0.10	0.13	0.15	0.34	NES	NES
6/14/77	c	c	c	c	c	c	c	c	c	c	c	c
7/ 7/77	82.00	55.30	0.30	0.02	0.05	0.23	0.10	0.09	NES	0.51	0.02	0.01
8/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
8/14/77	55.00	105.00	NES	0.01	0.03	0.17	0.10	NES	0.22	0.63	0.02	0.01
9/ 1/77	c	c	c	c	c	c	c	c	c	c	c	c
9/14/77	56.00	63.80	0.06	0.02	0.02	0.02	0.10	0.02	0.05	0.02	0.01	0.01
10/ 1/77	48.50	108.00	0.08	0.02	0.02	0.03	0.10	0.01	0.03	0.06	0.01	0.01
10/21/77	c	c	c	c	c	c	c	c	c	c	c	c
11/ 7/77	69.00	104.00	0.22	0.01	0.01	0.02	0.10	0.03	0.04	0.08	0.02	0.01
11/21/77	16.00	95.00	0.36	0.01	0.02	0.03	0.10	0.02	0.09	0.02	0.01	0.01
12/21/77	42.00	102.00	0.11	0.01	0.02	0.02	0.10	0.05	0.08	0.19	0.02	0.01
1/ 7/78	c	c	c	c	c	c	c	c	c	c	c	c
1/21/78	66.00	78.00	0.25	0.01	0.01	0.02	0.10	0.03	0.86	0.47	0.02	0.01

TABLE D-17 INDIVIDUAL SOIL ANALYSES, INITIAL SAMPLING (OCTOBER 1976)[a]

Site	Depth (cm)	B	Cl	F	NO_3-N	N	PO_4	P	P	K		Na		Ca	
		WE[d]	WE	WE	WE	T[e]	WE	AE[f]	Organic	WE[b]	EX[g]	WE[b]	AE[b]	WE[b]	E
Test	1	6.2	1170	1	75	1130	8.8	475	300	44	3180	134	16300	45	2850
		4.1	976	11	88	1260	22	1190	230	70	3780	142	10900	23	2350
		3.8	1610		11	1990		2130			3520				2770
	3	5.5	244	1	69	527	27	555	290	29	2630	110	20800	31	4430
		3.8	949	3	30	855	24	1960	210	95	4280	117	11300	14	7060
		2.9	1410		30	1270		2100			2780				4020
	10	4.7	976	1	4.5	445	15	410	< 20	51	3210	104	18600	46	6020
		1.2	1330	15	1.8	724	28	1300	< 20	75	3360	150	11300	17	3850
		2.6	3800		73	914		2110			2420				2720
	30	2.7	1630	1	23	443	12	400	60	59	3280	112	20000	20	3920
		2.5	1763	9	6.1	245	24	900	< 20	80	3880	161	11600	22	2640
		1.8	1180		<1.5	540		1570			2420				2640
	100	3.6	1600	1	51	84	12	340	< 20	45	2920	104	16900	21	9430
		2.2	461	5	31	233	20	700	70	78	2470	133	11500	13	5610
		4.4	786		5.6	352		945			2470				5640
	200	6.1	271	1	<1.0	106	1.0	315	150	63	3090	116	17900	11	2620
		3.0	1030	2	<1.0	168	9.0	340	40	81	3310	111	11300	13	3100
		2.5	1140		<1.0	10		380			3090				3740
	300	3.8	1630	1	1.8	60	12	150	50	59	3500	110	15700	19	1630
		3.4	1490	1	<1.0	10	11	422	20	102	2900	81	10200	14	2080
		1.3	1410		<1.0	67		425			3240				1630

(continued)

TABLE D-17 (continued)

Site	Depth (cm)	B	Cl	F^b	NO_3-N	N	PO_4	P^b	P Organic		K	Na		Ca	
		WE	WE	WE	WE	T	WE	AE		WE	EX	WE^2	AE^2	WE^2	EX
Control	1	3.8	397	16	< 1.0	267	1.8	830	250*	64	2000	149	5800	199	10100
		4.8	234	8	< 1.0	1310	< 1.0	955	20	87	1590	144	11500	39	10600
		3.4	280		< 1.0	736	< 1.0	950			1700				10400
	3	4.3	537	1	< 1.0	286	< 1.0	760	160	64	1510	201	7200	204	11600
		3.7	257	20	< 1.0	566	< 1.0	845	< 20	167	2370	166	12600	26	10500
		2.8	327		< 1.0	547	< 1.0	925			2070				12400
	10	3.5	280	4	< 1.0	88	< 1.0	780	100	38	2400	220	7500	199	10600
		3.5	818	6	< 1.0	622	< 1.0	935	50	203	2470	171	11700	19	12400
		3.2	257		< 1.0	443	< 1.0	885			2020				11900
	30	3.4	257	1	< 1.0	243	< 1.0	870	100	69	1210	238	8000	163	8200
		3.6	350	12	< 1.0	112	< 1.0	865	60	191	2370	183	11200	20	9200
		3.2	234		< 1.0	100	< 1.0	915			1960				11800
	100	3.6	234	9	< 1.0	787	< 1.0	670	< .20	54	2160	299	9800	97	11500
		3.5	257	1	< 1.0	102	< 1.0	840	100	188	1450	252	11100	18	10900
		3.2	327		< 1.0	58	< 1.0	500			1750				9900
	200	3.2	701	1	< 1.0	281	< 1.0	775	60	75	2250	300	11400	129	11500
		5.2	888	8	< 1.0	48	< 1.0	725	< 20	206	2890	262	12100	23	13200
		3.4	304		< 1.0	55	< 1.0	650			1690				10200
	300	2.8	304	1	< 1.0	222	< 1.0	438	80	38	1270	286	10900	90	13400
		4.6	1000	9	< 1.0	47	< 1.0	722	< 20	149	2000	294	9800	18	16800
		2.6	234		< 1.0	42	< 1.0	612			1050				11600

(continued)

TABLE D-17 (continued)

Site	Depth		Mg			CEC	Ag		Ba	Cd		Cr		Cu		Mn	
	(cm)	T	AE	WE	EX		T	AE^b	T^b	T^b	AE^b	T	AE^b	T	AE	T	AE
Test	1	10800	4500	37	743	28.3	<20	1.0	580	--	0.8	500	0.2	389	0.3	173	69
		17800	1220	29	619	27.4	<20	1.0	800	< 5	0.7	629	0.7	288	0.7	496	83
					668	26.1	<20			12		560		219		195	81
	3	11300	3850	33	751	33.0	<20	1.0	560	< 2	0.9	489	0.1	375	0.3	160	42
		27000	1020	31	563	32.6	<20	1.0	500	10	0.8	510	0.6	251	0.3	191	75
					799	31.7	<20		2			616		206		182	79
	10	11400	4550	36	605	25.2	<20	1.0	480	< 5	0.7	529	0.1	350	0.4	184	61
		19200	1080	26	395	24.8	<20	1.0	520	12	0.6	517	0.8	283	0.6	252	81
					418	24.3	<20					578		244		114	67
	30	12300	3550	27	697	22.2	<20	1.0	520	< 5	0.6	569	0.1	337	0.3	219	64
		15400	990	28	629	13.0	<20	1.0	540	8	0.4	500	0.5	243	0.3	212	59
					607	23.9	<20					458		146		293	53
	100	--	3350	20	580	12.2	<20	1.0	400	< 5	0.6	438	0.1	327	0.3	164	58
		15200	890	22	580	9.1	<20	1.0	540	12	0.3	460	0.3	265	0.3	236	48
					614	13.1	<20					517		152		150	70
	200	11000	2200	18	428	10.4	<20	1.0	520	< 5	0.6	529	0.1	270	0.3	170	59
		14600	970	24	413	11.3	<20	1.0	580	10	0.3	529	0.3	260	0.3	221	44
					541	10.9	<20					499		166		239	42
	300	6420	3400	16	554	12.2	<20	1.0	580	< 5	0.5	469	0.1	280	0.3	215	49
		7600	780	28	351	10.4	<20	1.0	580	4	0.4	400	0.3	217	0.3	199	47
					655	15.6	<20					469		156		120	48

(continued)

TABLE D-17 (continued)

Site	Depth	Mg				CEC[10]	Ag		Ba	Cd		Cr		Cu		Mn	
	(cm)	T	AE[b]	WE[b]	E		T	AE[b]	T[b]	T	AE[b]	T	AE[b]	T	AE[b]	T	AE
Control	MCI	13500	2000		649	23.0	<20	<1.0	500	--	1.5	638	0.4	176	0.9	497	44
		18600	1210	38	315	21.3	<20	<1.0	560	<5	0.3	538	0.3	155	0.3	444	37
					826	17.5	<20			6		617		152		478	33
	3	12800	2000		680	20.9	<20	<1.0	540	<5	2.0	459	0.4	148	0.5	435	34
		19000	1000	36	812	20.0	<20	<1.0	540	8	0.5	537	0.3	143	0.4	442	33
					624	16.5	<20					618		174		463	33
	10	13000	2300		769	20.0	<20	<1.0	480	<5	1.9	557	0.3	138	0.5	393	41
		23200	1000	31	367	20.9	<20	<1.0	540	<5	0.2	640	0.3	196	0.3	507	24
					738	17.8	<20					437		157		302	23
	30	13300	1800		317	13.9	<20	<1.0	480	<5	1.7	596	0.3	119	0.5	410	32
		18000	1150	33	515	13.5	<20	<1.0	520	6	0.3	659	0.3	183	0.3	457	31
					778	12.6	<20					507		162		454	27
	100	13100	2100		559	13.5	<20	<1.0	460	<5	1.9	536	0.4	114	2.0	510	20
		28800	1040	30	593	12.2	<20	<1.0	500	<5	0.5	688	0.2	170	0.3	469	30
					660	13.0	<20					629		143		494	19
	200	13100	1800		673	12.2	<20	<1.0	520	<5	1.1	670	0.2	138	0.4	571	27
		21400	900	26	490	10.0	<20	<1.0	500	6	0.3	589	0.3	153	0.3	390	27
					362	10.9	<20					539		132		480	5
	300	15300	1900		738	15.6	<20	<1.0	540	<5	1.5	536	0.3	151	0.2	551	26
		7200	1240	23	779	9.6	<20	<1.0	680	6	0.3	589	0.2	122	0.2	456	20
					329	10.0	<20					529		84		420	18

(continued)

TABLE D-17 (continued)

Site	Depth (cm)	Mo	Ni		Pb		Zn		As		Hg		Se		pH
		T	T	AE	T	AE	T	AE	T	AE	T	AE	T	AE	
Test	1	<20	100	1.3	66	1.5	84	6.8	2.6	<0.1					7.5
		<20	78	1.4	90			3.9	2.1	0.3	<0.5	<0.05	<2.0	<0.10	7.7
	3	<20	136	1.7	62	1.2	94	7.9	4.0	0.3	<0.5	<0.05	<2.0	<0.10	7.6
		<20	88	0.5	36			2.5	2.0	<0.1					7.9
	10	<20	114	1.7	66	1.9	92	7.5	5.4	0.3	<0.5	<0.05	<2.0	<0.10	8.1
		<20	84	1.1	40			5.1	2.0	<0.1					8.0
	30	<20	100	2.1	44	1.4	82	3.9	5.7	0.3	<0.5	<0.05	<2.0	<0.10	8.4
		<20	82	0.5	30			1.9	2.3	<0.1					8.3
	100	<20	108	2.0	52	2.1	70	3.6	4.7	0.2	<0.5	<0.05	<2.0	<0.10	8.5
		<20	94	0.8	16			1.2	2.0	<0.1					8.4
	200	<20	100	2.6	38	2.0	76	1.7	4.5	0.1	<0.5	<0.05	<2.0	<0.10	8.5
		<20	66	0.5	36			0.9	2.2	<0.1					8.9
	300	<20	90	1.5	40	1.2	64	2.2	2.1	0.2	<0.5	<0.05	<2.0	<0.10	8.6
		<20	60	0.3	38			0.8	3.7	<0.1					8.0
Control	1	<20	116	0.6	60	3.0	106	1.4	6.0	<0.1					7.7
		<20	78	0.7	30			0.3	4.1	0.3	<0.5	<0.05	<2.0	<0.10	7.6
	3	<20	112	1.1	72	2.1	128	1.3	8.2	0.4	<0.5	<0.05	<2.0	<0.10	7.9
		<20	78	1.0	34			0.3	4.8	<0.1					8.1
	10	<20	90	0.9	72	1.9	94	1.2	8.6	0.4	<0.5	<0.05	<2.0	<0.10	8.0
		<20	84	1.5	30			0.3	4.8	<0.1					8.0
	30	<20	118	1.0	40	2.4	80	1.1	11.0	0.3	<0.5	<0.05	<2.0	<0.10	8.3
		<20	88	1.7	30			0.3	4.7	<0.1					8.4
	100	<20	86	0.9	54	1.5	104	1.4	6.2	0.3	<0.5	<0.05	<2.0	<0.10	8.4
		<20	84	1.0	38			0.4	4.9	<0.1					8.4
	200	<20	246	1.2	58	1.5	88	0.9	5.8	0.2	<0.5	<0.05	<2.0	<0.10	8.9
		<20	74	2.6	42			0.4	3.7	<0.1					8.4
	300	<20	306	1.6	52	1.6	76	0.8	6.4	0.3	<0.5	<0.05	<2.0	<0.10	8.0
		<20	64	2.1	18			1.6	2.2	<0.1					8.7

(continued)

TABLE D-17(continued)

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[a] All values in mg/kg unless noted.
[b] Analyses done on a composite of three samples, additional analysis in progress.
[c] N = NO_3-N + KjN.
[d] WE = water extractible.
[e] T = Total.
[f] AE = acid extractible.
[g] EX = exchangeable.
[h] AIP = analysis in progress.
[i] ND = not detected.
[i] meg/100 gm.

TABLE D-18. INDIVIDUAL SOIL ANALYSES FINAL SAMPLING (DECEMBER 1977)[a]

Site	Depth (cm)	B	Cl	F	NO_3-N	N	PO_4-P	P	P Organic	K		Na		Ca	
		WE[c]	WE	WE	WE	T[d]	WE	AE[e]	T	WE	EX[f]	WE	AE	WE	EX
Test	1	3.5	288	3	48	319	--	106	180	150	1270	409	15500	2.8	2750
		1.7	325	1	59	146	25	114	220	95	1150	436	15500	12.0	1740
	3	2.6	87	10	30	434	10	110	< 20	262	990	704	16700	2.0	2190
		1.8	299	1	43	320	15	71	370	62	1220	386	13700	18.9	1790
	10	1.8	10	3	22	126	19	64	50	113	1110	331	19000	6.1	1930
		1.2	149	3	23	219	22	19	270	94	1240	393	15700	7.5	1990
	30	1.0	75	1	6.0	16	16	29	80	66	1080	293	18500	8.5	2120
		0.9	125	1	46	141	12	23	130	82	1020	304	16700	3.0	1810
	100	0.9	125	1	25	140	13	34	30	60	970	280	19500	7.4	1490
		0.7	50	3	10	62	15	29	90	82	1020	252	13000	5.7	1744
	200	0.7	25	1	7.5	17	12	41	80	50	870	192	19300	10.0	1680
		0.6	50	1	6.0	16	--	114	170	79	810	179	8250	12.3	1550
	300	0.8	10	1	5.0	15	--	32	190	50	870	172	12700	7.0	1430
		0.9	10	1	3.7	14	6.0	11	90	40	770	151	15500	6.6	1490
Control	1	1.3	299	1	105	674	1.6	56	180	94	1540	485	16500	--	2870
		1.5	549	1	270	963	0.7	11	60	90	1430	536	12000	--	2490
	3	0.9	199	4	38	482	3.7	13	220	124	1270	387	12300	6.6	2060
		1.7	149	6	36	665	10	33	<20	300	1020	345	15500	15.7	2230
	10	0.8	125	4	21	662	3.7	14	270	107	1140	355	14700	11.5	2300
		0.6	125	6	13	590	4.2	34	<20	102	1160	307	12700	5.6	3180
	30	0.7	125	2	4.0	252	1.8	21	80	99	1080	292	17000	7.9	2680
		0.8	75	2	1.5	252	4.8	30	30	88	1180	320	16700	7.2	1990
	100	1.4	75	6	4.0	252	3.5	16	50	218	1280	468	17300	6.6	2370
		0.9	125	5	8.5	233	4.4	16	90	122	1100	418	16700	3.8	1810
	200	2.9	149	17	50	183	20	6.5	< 20	348	380	936	15300	3.7	1560
		2.6	25	9	22	80	9.6	6.5	< 20	235	500	736	16500	2.0	1500
	300	2.1	375	12	31	150	14	14	50	358	280	941	14500	4.3	1560
		1.8	275	9	28	91	6.9	16	< 20	142	480	816	15700	2.0	1560

(continued)

TABLE D-18 (continued)

Site	Depth	Mg				CEC^g	Ag		Ba	Cd		Cr		Cu		Mn	
	(cm)	T	AE	WE	EX		T	AE	T	T	AE	T	AE	T	AE	T	AE
Test	1	6600	6600	12.1	400	11.6	< 20	< 1.0	474	<5	0.2	234	0.2	38	0.7	660	59
		3300	5900	15.8	409	12.0	< 20	< 1.0	584	<5	0.3	244	0.3	28	0.7	592	54
	3	6800	5150	16.2	375	12.2	< 20	< 1.0	476	<5	0.2	192	0.2	36	0.6	604	52
		--	5850	18.0	332	11.5	< 20	< 1.0	400	<5	0.2	220	0.2	26	0.6	592	45
	10	7500	4650	10.5	326	14.6	< 20	< 1.0	516	<5	0.2	230	0.2	38	0.5	612	31
		--	4750	10.0	537	19.0	< 20	< 1.0	380	<5	0.2	238	0.2	30	0.6	588	25
	30	8400	4900	10.0	434	16.5	< 20	< 1.0	542	<5	0.1	238	0.3	42	0.5	618	27
		6850	5100	7.6	352	12.1	< 20	< 1.0	392	<5	0.3	228	0.3	28	0.6	628	28
	100	6600	4500	7.9	267	8.8	< 20	< 1.0	444	<5	0.2	206	0.2	25	0.4	620	37
		7400	5400	8.0	273	11.8	< 20	< 1.0	382	<5	0.3	220	0.3	20	0.6	596	28
	200	6450	4600	9.5	150	6.8	< 20	< 1.0	384	<5	0.2	288	0.2	22	0.9	762	46
		5000	1900	11.8	151	7.4	< 20	< 1.0	398	<5	0.2	246	0.2	16	2.4	700	32
	300	6150	4900	7.7	186	7.4	< 20	< 1.0	358	<5	0.2	274	0.2	56	0.6	762	38
		7250	4750	7.5	152	7.0	< 20	< 1.0	464	<5	0.3	320	0.3	28	0.8	690	47
Control	1	6500	2550	40.0	851	26.4	< 20	< 1.0	638	<5	0.3	188	0.1	34	0.7	632	19
		12500	5000	70.5	929	31.6	< 20	< 1.0	962	<5	0.2	556	0.2	67	0.6	1096	30
	3	8900	4100	13.2	877	25.1	< 20	< 1.0	578	<5	0.3	190	0.2	34	0.6	630	13
		12000	3150	19.1	637	25.4	< 20	< 1.0	928	<5	0.2	366	0.2	62	0.6	1024	21
	10	16700	5300	14.0	1200	24.1	< 20	< 1.0	750	<5	0.2	402	0.2	60	0.6	1088	18
		17500	4250	11.5	723	24.5	< 20	< 1.0	1034	<5	0.2	532	0.2	62	0.6	1046	25
	30	12700	2350	9.2	678	19.8	< 20	< 1.0	1086	<5	0.2	358	0.3	54	0.5	1010	14
		9500	1900	10.6	1050	20.1	< 20	< 1.0	1028	<5	0.3	444	0.4	58	0.6	1004	15
	100	15300	4000	13.3	749	26.7	< 20	< 1.0	1176	<5	0.2	374	0.5	62	0.5	1084	17
		18700	2150	10.3	690	21.3	< 20	< 1.0	870	<5	0.3	440	0.1	64	0.7	1164	10
	200	12000	4000	45.5	751	13.0	< 20	< 1.0	674	<5	0.2	432	0.2	40	0.5	980	22
		9000	2100	15.2	1150	15.0	< 20	< 1.0	498	<5	0.3	372	0.2	46	0.5	920	20
	300	10700	3150	22.5	649	16.2	< 20	< 1.0	776	<5	0.2	428	0.1	58	0.5	1174	29
		8500	1800	12.3	457	11.7	< 20	< 1.0	642	<5	0.2	540	0.2	38	0.5	1180	23

(continued)

TABLE D-18. (continued)

Site	Depth (cm)	Mo	Ni		Pb		Zn		As		Hg		Se	
		T	T	AE	T	AE	T	AE	T	AE	T	AE	T	AE
Test	1	< 20	56	1.7	160	6.3	5.5	1.7	<2.0	0.2	<0.5	< 0.05	--	<0.1
		< 20	54	1.5	114	9.4	6.7	1.4	4.4	0.2	< 0.5	< 0.05	<2.0	<0.1
	3	< 20	56	0.9	150	6.5	5.4	1.6	4.0	0.2	< 0.5	< 0.05	4.8	<0.1
		< 20	52	1.5	114	9.9	4.6	0.9	<2.0	0.2	<0.5	< 0.05	<2.0	<0.1
	10	< 20	62	1.2	162	7.3	5.8	0.8	3.7	0.1	<0.5	< 0.05	5.3	<0.1
		< 20	42	1.2	172	8.9	5.0	0.7	<2.0	0.2	<0.5	< 0.05	4.8	<0.1
	30	< 20	60	0.9	140	8.0	6.3	0.7	6.2	0.2	< 0.5	< 0.05	2.1	<0.1
		< 20	58	1.3	96	9.4	6.7	0.7	3.7	0.2	<0.5	< 0.05	<2.0	<0.1
	100	< 20	54	1.5	162	7.4	4.6	0.9	<2.0	0.2	<0.5	< 0.05	3.2	<0.1
		< 20	58	1.3	122	8.1	4.2	0.6	<2.0	0.1	<0.5	< 0.05	24	<0.1
	200	< 20	60	1.8	136	8.4	5.4	2.1	2.0	0.2	<0.5	< 0.05	2.5	<0.1
		< 20	62	1.1	128	9.0	4.4	3.5	2.2	0.3	<0.5	< 0.05	24	<0.1
	300	< 20	54	1.6	114	9.8	5.6	0.8	<2.0	0.3	<0.5	< 0.05	<2.0	<0.1
		< 20	60	1.2	120	8.7	5.4	3.2	<2.0	0.2	<0.5	< 0.05	9.4	<0.1
Control	1	< 20	60	1.7	160	10.2	4.8	0.5	2.0	0.4	<0.5	< 0.05	20.0	<0.1
		< 20	128	1.3	188	9.5	9.9	0.3	4.8	0.4	<0.5	< 0.05	25.0	<0.1
	3	< 20	58	1.6	124	9.1	6.9	0.8	4.7	0.3	<0.5	< 0.05	4.6	<0.1
		< 20	124	1.1	216	10.0	9.5	0.6	5.8	0.3	<0.5	< 0.05	13.0	<0.1
	10	< 20	138	1.6	254	9.8	9.2	0.6	6.5	0.4	<0.5	< 0.05	23.0	<0.1
		< 20	130	1.4	216	9.5	9.4	0.6	5.8	0.3	<0.5	< 0.05	11.0	<0.1
	30	< 20	118	1.5	174	9.9	8.6	0.5	4.5	0.4	<0.5	< 0.05	22.0	<0.1
		< 20	130	1.2	218	8.4	8.7	0.6	6.8	0.3	<0.5	< 0.05	6.3	<0.1
	100	< 20	126	1.3	254	9.4	9.3	0.5	<2.0	0.2	< 0.5	< 0.05	3.8	<0.1
		< 20	124	1.1	264	9.1	8.6	0.5	<2.0	0.3	< 0.5	< 0.05	13.0	<0.1
	200	< 20	102	1.4	140	9.4	7.7	0.4	6.8	0.2	< 0.5	< 0.05	--	<0.1
		< 20	108	1.3	190	8.1	7.2	0.7	2.1	0.3	<0.5	< 0.05	10.0	<0.1
	300	< 20	128	1.3	196	10.2	10.0	0.3	4.3	0.2	<0.5	< 0.05	4.5	<0.1
		< 20	130	1.6	240	7.3	8.2	0.7	2.1	0.2	< 0.5	< 0.05	20.0	<0.1

(continued)

TABLE D-18. (continued)

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[a] All values in mg/kg unless noted.

[b] NO_3-N + K_TN.

[c] WE = Water extractible.

[d] T = Total.

[e] AE = Acid extractible.

[f] EX = Exchangeable.

[g] meq/100 gm.

APPENDIX E

STATISTICAL TABLES

TABLE E-1. STATISTICAL COMPARISON BETWEEN TEST EFFLUENT AND CONTROL IRRIGATION WATER

M.T.EFFLUENT	* MPN/100 ml *				Constituent(mg/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	21	20	15	20	19	16	14	10	15	17	18	21	21
MEAN	3.09E+06	1.05E+05	1044.13	0.44	356.26	1.41	1.71	24.91	58.90	9.01	67.22	18.09	215.60
STD. DEV.	1.27E+07	2.83E+05	289.47	0.17	96.79	0.50	1.94	5.21	22.66	1.75	16.27	4.38	70.42

M.T.EFFLUENT					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	17	19	20	21	20	20	17	18	21	18	18	17
MEAN	46.76	41.78	0.16	0.02	0.04	0.08	0.10	0.07	0.08	0.06	0.01	0.01
STD. DEV.	18.57	17.43	0.11	0.02	0.03	0.05	0.00	0.05	0.05	0.03	0.01	0.00

M.C.IRRIGATION* MPN/100 ml *					Constituent(mg/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	18	17	18	16	16	17	16	12	14	15	16	16	16
MEAN	11315.94	1028.24	816.44	0.19	254.13	0.52	2.75	3.53	19.86	0.49	54.01	6.44	149.78
STD. DEV.	36921.54	3751.82	216.28	0.07	61.33	0.26	1.94	1.98	17.69	0.58	10.86	1.33	38.52

M.C.IRRIGATION					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	16	17	14	17	17	18	13	18	17	15	14	13
MEAN	42.53	37.39	0.13	0.01	0.03	0.08	0.10	0.05	0.05	0.03	0.02	0.01
STD. DEV.	9.84	17.70	0.05	0.01	0.02	0.07	0.00	0.04	0.04	0.02	0.01	0.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($)						/ PAGE 1	7/5/78						
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
H-TEST	$75	69.00	98.00	99.00	99.00	99.00	85.00	99.00	99 00	99.00	99.00	99.00	99.00
CHI-SQUARE	99.00	99.00	95.00	99.00	99.00	99.00	$80	99 00	90 00	99.00	99.00	99.00	99.00
T-TEST	$80	80.00	95.00	99.00	99.00	99.00	80 00	99.00	99 00	99 00	95.00	99.00	99.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($)						/ PAGE 2	7/5/78					
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
H-TEST	$75	$75	$75	$75	85.00	$75		$75	95.00	99.00	$75	$75
CHI-SQUARE	99.00	$80	99.00	99.00	99.00	80.00		90.00	99 00	$80	99.00	
T-TEST	$80	$80	$80	$80	80.00	$80		$80	90.00	99.00	$80	$80

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TABLE E-2. STATISTICAL COMPARISON BETWEEN TEST AND CONTROL LEACHATE AT 50 CM

MTL-50	* MPN/100 ml *				Constituent(mg/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	7	7	6	4	4	4	4	3	3	4	4	5	5
MEAN	0.00	0.00	1507.50	0.34	379.75	0.85	59.38	54.73	8.33	4.98	110.50	15.04	222.20
STD. DEV.	0.00	0.00	337.25	0.11	61.84	0.17	17.26	13.99	1.89	3.39	45.42	2.96	70.00

MTL-50	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	5	5	5	5	5	5	5	5	5	5	4	4
MEAN	70.80	51.03	0.22	0.01	0.02	0.05	0.10	0.05	0.07	0.19	0.01	0.01
STD. DEV.	34.43	6.22	0.07	0.00	0.01	0.02	0.00	0.03	0.03	0.06	0.00	0.00

MCL-50	* MPN/100 ml *				Constituent(mg/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	1	1	1	1	1	0	1	0	0	1	1	0	1
MEAN	20.00	0.00	1242.00	0.45	486.00		18.00			1.00	144.00		285.00
STD. DEV.	0.00	0.00	0.00	0.00	0.00		0.00			0.00	0.00		0.00

MCL-50	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	0	0	0	1	1	0	0	1	1	1	1	1
MEAN				0.01	0.03			0.09	0.12	0.32	0.01	0.01
STD. DEV.				0.00	0.00			0.00	0.00	0.00	0.00	0.00

*LEVELS OF CONFIDENCE OF DIFFERENCE (%) / PAGE 1 7/5/78

	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
H-TEST			94.00	95.00	99.00		99.00			98.00	86.00		95.00
CHI-SQUARE													
T-TEST			$80	$80	$80		80.00			$80	$80		$80

*LEVELS OF CONFIDENCE OF DIFFERENCE ($) / PAGE 2 7/5/78

	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
H-TEST				$75	90.00			99.00	99.00	99.00	75.00	
CHI-SQUARE												
T-TEST				$80	$80			$80	$80	80.00	$80	

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TABLE E-3. STATISTICAL COMPARISON BETWEEN TEST AND CONTROL LEACHATE AT 100 CM

MTL-100	* MPN/100 ml *		Constituent(mg/l)										
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	9	9	7	5	6	6	5	4	4	5	6	6	6
MEAN	8.89	8.89	1342.14	0.48	315.98	1.10	50.50	46.43	16.13	4.24	176.33	15.55	306.00
STD. DEV.	25.14	25.14	338.00	0.35	68.13	0.37	17.65	15.72	13.71	2.86	118.37	6.45	134.53

MTL-100	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	6	5	5	5	6	5	3	6	6	6	4	4
MEAN	101.53	39.44	0.16	0.02	0.05	0.06	0.10	0.10	0.06	0.16	0.01	0.01
STD. DEV.	73.75	13.00	0.03	0.01	0.02	0.01	0.00	0.07	0.01	0.05	0.00	0.00

MCL-100	* MPN/100 ml *		Constituent(mg/l)										
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	2	2	1	2	2	2	1	1	0	2	2	2	2
MEAN	60.00	25.00	868.00	0.22	353.50	1.06	18.50	19.30		3.58	84.50	15.60	211.00
STD. DEV.	20.00	25.00	0.00	0.12	3.50	0.04	0.00	0.00		1.82	15.50	7.40	37.00

MCL-100	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	2	3	2	2	2	2	3	1	2	3	1	1
MEAN	25.00	61.09	0.16	0.01	0.05	0.16	0.10	0.31	0.09	0.37	0.01	0.01
STD. DEV.	3.00	7.16	0.06	0.00	0.04	0.15	0.00	0.00	0.03	0.06	0.00	0.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($) / PAGE 1 7/6/78

	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
H-TEST	99.00	$75	99.00	86.00	82.00	$75	99.00	99.00		$75	93.00	$75	88.00
CHI-SQUARE	$80	$80		99.00	99.00	99.00				95.00	99.00	$80	99.00
T-TEST	95.00	$80	$80	$80	$80	$80	$80	$80		$80	$80	$80	$80

*LEVELS OF CONFIDENCE OF DIFFERENCE ($) / PAGE 2 7/6/78

	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
H-TEST	99.00	99.00	$75	84.00	$75	$75		99.00	85.00	99.00	75.00	
CHI-SQUARE	99.00	99.00	$80		$80	99.00			90.00	$80		
T-TEST	$80	90.00	$80	$80	$80	$80		90.00	80.00	99.00	$80	

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TABLE E-4. STATISTICAL COMPARISON BETWEEN TOP LEVELS OF CONTROL WELLS 1 AND 2.

MCW-2-T	* MPN/100 ml *				Constituent(mg/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	16	16	15	9	12	9	10	8	8	9	8	9	9
MEAN	76.25	0.00	1330.27	0.41	397.75	0.68	5.71	7.54	33 94	0 52	117.00	10.09	288.11
STD. DEV.	133.46	0.00	283.73	0.11	95.49	0.30	5.46	5.50	33 75	0.76	35.58	3 71	68.26

MCW-2-T					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	9	8	7	10	9	9	10	9	10	9	9	9
MEAN	58.16	90.67	0.17	0.01	0.03	0.06	0.11	0.05	0.15	0 18	0.01	0.01
STD. DEV.	22.30	37.52	0.08	0.01	0.02	0.05	0.03	0.04	0.10	0.16	0.00	0.00

MCW-1-T	* MPN/100 ml *				Constituent(mg/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	14	14	15	9	13	8	10	8	9	10	7	8	9
MEAN	47.14	0.00	1016.33	0.47	298.23	0.46	4.46	6.04	30.62	1.50	65.60	9.45	177.33
STD. DEV.	126.01	0.00	196.58	0.09	43.98	0.28	2.58	2.70	19.87	1.62	15.17	0.51	34.63

MCW-1-T					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	9	8	8	10	9	9	10	9	9	8	9	9
MEAN	63.44	72.90	0.20	0.01	0.03	0.04	0.10	0.05	0.32	0.31	0.02	0.01
STD. DEV.	15.62	26.84	0.10	0.00	0.02	0.03	0.00	0.03	0.30	0.24	0.01	0.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($)					/ PAGE 1	7/6/78							
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
H-TEST	$75		99.00	$75	99.00	83 00	$75	$75	$75	90 00	99.00	$75	99 00
CHI-SQUARE	$80		99.00	$80	99.00	$60	99.00	99 00	99 00	95 00	99.00	99.00	99.00
T-TEST	$80		99.00	$80	99.00	80 00	$80	$80	$80	80 00	99.00	$80	99.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($)					/ PAGE 2	7/6/78					
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
H-TEST	$75	$75	$75	$75	$75	$75	$75	$75	89.00	82.00	82.00	
CHI-SQUARE	90.00	90.00	$80	99.00	$80	99.00		90.00	99.00	80.00	90.00	
T-TEST	$80	$80	$80	$80	$80	$80	$60	$80	80.00	$60	$60	

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TABLE E-5. STATISTICAL COMPARISON BETWEEN BOTTOM LEVELS OF CONTROL WELLS 1 AND 2

MCW-2-B	* MPN/100 ml *				Constituent(mg/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	13	13	15	9	10	7	8	7	9	8	8	9	9
MEAN	43.85	3.85	1359.53	0.40	423.20	0.64	8.26	10.17	24.89	0.41	113.25	10.97	262.00
STD. DEV.	92.70	13.32	246.57	0.11	95.64	0.31	5.19	4.79	23.44	0.37	24.28	4.84	54.36

MCW-2-B					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	8	9	8	9	9	9	9	8	7	8	9	8
MEAN	75.86	95.52	0.16	0.01	0.03	0.08	0.10	0.06	0.09	0.18	0.01	0.01
STD. DEV.	22.68	32.37	0.10	0.00	0.02	0.09	0.00	0.06	0.09	0.11	0.00	0.00

MCW-1-B	* MPN/100 ml *				Constituent(mg/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	13	13	15	9	10	9	7	8	8	7	6	8	8
MEAN	1885.38	6.15	1054.73	0.49	307.60	0.52	4.59	6.63	21.74	0.67	68.17	9.49	165.00
STD. DEV.	6384.36	21.32	256.54	0.09	36.53	0.35	0.74	3.40	23.30	0.47	15.53	1.07	26.95

MCW-1-B					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	8	9	8	9	9	8	9	8	7	8	9	9
MEAN	60.19	73.56	0.22	0.01	0.03	0.06	0.11	0.05	0.13	0.26	0.02	0.01
STD. DEV.	12.07	24.33	0.10	0.01	0.02	0.03	0.03	0.04	0.13	0.21	0.01	0.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($) / PAGE 1 7/6/78

	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
H-TEST	$75	$75	99.00	95.00	99.00	$75	95.00	89.00	$75	75.00	99.00	$75	99.00
CHI-SQUARE	99.00	90.00	$80	$80	99.00	$80	99.00	90.00	$80	$80	99.00	99.00	99.00
T-TEST	$80	$80	99.00	90.00	99.00	$80	80.00	60.00	$80	$80	99.00	$80	99.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($) / PAGE 2 7/6/78

	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
H-TEST	91.00	89.00	75.00	$75	$75	$75	$75	$75	$75	$75	98.00	
CHI-SQUARE	99.00	80.00	$80	$80	$80	99.00	99.00	99.00	$80	80.00	80.00	
T-TEST	80.00	80.00	$80	$80	$80	$80	$80	$80	$80	$80	95.00	

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TABLE E-6. STATISTICAL COMPARISON BETWEEN TOP LEVELS OF TEST WELLS 1 AND 3.

MTW-3-T	* MPN/100 ml *		Constituent(mg/l)										
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	14	14	13	9	12	9	9	7	9	9	7	8	9
MEAN	1185.71	100.00	1134.62	0.60	339.92	0.42	12.01	15.21	26.10	1.73	84.00	8.96	227.89
STD. DEV.	4109.05	360.56	278.99	0.10	49.18	0.34	7.67	7.41	23.23	2.02	18.54	2.13	43.19

MTW-3-T	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	9	8	9	10	9	9	10	9	8	8	9	9
MEAN	59.87	78.52	0.24	0.01	0.03	0.07	0.12	0.05	0.14	0.22	0.02	0.01
STD. DEV.	9.07	24.59	0.17	0.00	0.02	0.05	0.06	0.03	0.20	0.26	0.01	.0.00

MTW-1-T	* MPN/100 ml *		Constituent(mg/l)										
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	15	15	13	9	12	8	11	7	8	9	6	8	9
MEAN	1818.67	1.33	727.85	0.32	233.75	0.43	6.89	9.07	18.86	1.01	66.00	7.55	156.11
STD. DEV.	4444.99	4.99	64.94	0.09	26.79	0.40	4.22	4.48	14.28	0.54	11.70	1.66	23.75

MTW-1-T	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	9	8	8	10	9	9	10	9	9	7	9	6
MEAN	30.82	36.32	0.15	0.01	0.02	0.08	0.12	0.05	0.19	0.18	0.02	0.01
STD. DEV.	5.34	14.38	0.08	0.00	0.02	0.07	0.06	0.06	0.23	0.12	0.01	0.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($) / PAGE 1 7/6/78

	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
H-TEST	$75	$75	99.00	99.00	99.00	$75	92.00	93.00	$75	$75	96.00	85.00	99.00
CHI-SQUARE	$80	99.00	99.00	$80	99.00	$80	99.00	99.00	99.00	99.00	99.00	80.00	99.00
T-TEST	$80	$80	99.00	99.00	99.00	$80	90.00	80.00	$80	$80	90.00	80.00	99.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($) / PAGE 2 7/6/78

	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
H-TEST	99.00	99.00	85.00	$75	$75	$75	$75	$75	$75	$75	$75	
CHI-SQUARE	99.00	99.00	99.00	$80	$80	$80	$80	90.00	$80	99.00	$80	
T-TEST	99.00	99.00	$80	$80	$80	$80	$80	$80	$80	$80	$80	

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TABLE E-7. STATISTICAL COMPARISON BETWEEN BOTTOM LEVELS OF TEST WELLS 1 AND 2

MTW-3-B	* MPN/100 ml *		Constituent(mg/l)										
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	13	13	13	9	10	8	8	7	8	9	7	9	9
MEAN	93.85	1.54	1193.23	0.61	357.00	0.79	9.92	11.90	31.13	2.11	78.14	11.66	216.67
STD. DEV.	109.16	5.33	187.26	0.10	33.86	0.69	5.30	4.77	14.32	2.50	13.27	8.40	45.63

MTW-3-B	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	9	9	8	9	9	9	9	8	8	9	8	8
MEAN	58.94	83.80	0.19	0.01	0.03	0.07	0.10	0.05	0.19	0.26	0.02	0.01
STD. DEV.	21.91	23.10	0.11	0.00	0.02	0.07	0.00	0.04	0.26	0.22	0.01	0.00

MTW-1-B	* MPN/100 ml *		Constituent(mg/l)										
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	13	13	13	9	10	7	9	8	9	8	7	9	9
MEAN	873.85	3.08	733.69	0.29	246.90	0.34	5.79	7.11	31.28	1.18	71.86	8.42	158.22
STD. DEV.	1789.61	7.22	93.63	0.05	55.02	0.24	2.46	2.33	20.58	0.78	20.12	2.23	23.20

MTW-1-B	Constituent(mg/l)											
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	9	8	8	9	9	9	9	8	8	8	9	8
MEAN	30.76	39.77	0.16	0.01	0.03	0.08	0.11	0.05	0.13	0.32	0.03	0.01
STD. DEV.	6.26	14.41	0.07	0.00	0.03	0.06	0.03	0.03	0.09	0.28	0.03	0.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($)						/ PAGE 1 7/6/78							
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
H-TEST	86.00	$75	99.00	99.00	99.00	92.00	95.00	98.00	$75	$75	$75	$75	99.00
CHI-SQUARE	99.00	$80	99.00	99.00	80.00	99.00	99.00	99.00	$80	99.00	$80	99.00	99.00
T-TEST	80.00	$80	99.00	99.00	99.00	80.00	90.00	95.00	$80	$80	$80	$80	99.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($)						/ PAGE 2 7/6/78						
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
H-TEST	99.00	99.00	$75	$75	$75	$75	$75	$75	$75	$75	$75	
CHI-SQUARE	99.00	99.00	99.00	$80	90.00	$80	99.00	80.00	99.00	$80	99.00	
T-TEST	99.00	99.00	$80	$80	$80	$60	$80	$80	$80	$80	$80	

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TABLE E-8. STATISTICAL COMPARISON BETWEEN TOP LEVELS OF TEST WELLS 2 AND 3

MTW-3-T	* MPN/100 ml *				Constituent(mc/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	14	14	13	9	12	9	9	7	9	9	7	8	9
MEAN	1185.71	100.00	1134.62	0.60	339.92	0.42	12.01	15.21	26.10	1.73	84.00	8.96	227.89
STD. DEV.	4109.05	360.56	278.99	0.10	49.18	0.34	7.67	7.41	23.23	2.02	18.54	2.13	43.19

MTW-3-T					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	9	8	9	10	9	9	10	9	8	8	9	9
MEAN	59.87	76.52	0.24	0.01	0.03	0.07	0.12	0.05	0.14	0.22	0.02	0.01
STD. DEV.	9.07	24.59	0.17	0.00	0.02	0.05	0.06	0.03	0.20	0.26	0.01	0.00

MTW-2-T	* MPN/100 ml *				Constituent(mg/l)								
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	13	13	12	8	11	7	8	8	8	6	6	8	8
MEAN	58.46	0.00	695.50	0.30	224.18	0.53	4.91	6.45	25.19	0.61	82.17	7.21	158.00
STD. DEV.	107.19	0.00	102.32	0.09	25.90	0.31	2.00	1.85	27.07	0.41	26.14	1.27	23.67

MTW-2-T					Constituent(mg/l)							
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	9	7	7	9	8	9	9	9	8	8	8	8
MEAN	35.06	44.21	0.21	0.01	0.04	0.07	0.10	0.03	0.13	0.33	0.02	0.01
STD. DEV.	17.45	11.24	0.14	0.00	0.05	0.06	0.00	0.02	0.11	0.25	0.02	0.00

*LEVELS OF CONFIDENCE OF DIFFERENCE (%)						/ PAGE 1	7/6/78						
	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
H-TEST	$75	$75	99.00	99.00	99.00	$75	99.00	99.00	$75	89.00	$75	95.00	99.00
CHI-SQUARE	99.00		99.00	$80	99.00	$80	99.00	99.00	$80	99.00	$80	99.00	99.00
T-TEST	$80	$60	99.00	99.00	99.00	$60	95.00	95.00	$60	$60	$80	90.00	99.00

*LEVELS OF CONFIDENCE OF DIFFERENCE (%)						/ PAGE 2	7/6/78					
	Ca	Mg	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
H-TEST	99.00	99.00	$75	$75	$75	$75	$75	90.00	$75	$75	$75	
CHI-SQUARE	90.00	99.00	$80	$80	99.00	$80		99.00	99.00	$80	95.00	
T-TEST	99.00	99.00	$80	$80	$80	$80	$80	80.00	$80	$80	$80	

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TABLE E-9. STATISTICAL COMPARISON BETWEEN BOTTOM LEVELS OF TEST WELLS 2 AND 3

MTw-3-B	* MPN/100 ml * TC	FC	TDS	B	Constituent(mg/l) Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	13	13	13	9	10	8	8	7	8	9	7	9	9
MEAN	93.85	1.54	1193.23	0.61	357.00	0.79	9.92	11.90	31.13	2.11	76.14	11.66	216.67
STD. DEV.	109.16	5.33	187.26	0.10	33.86	0.69	5.30	4.77	14.32	2.50	13.27	8.40	45.63

MTw-3-B	Ca	Mg	Ba	Cd	Constituent(mg/l) Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	9	9	8	9	9	9	9	8	8	9	8	8
MEAN	58.94	83.80	0.19	0.01	0.03	0.07	0.10	0.05	0.19	0.26	0.02	0.01
STD. DEV.	21.91	23.10	0.11	0.00	0.02	0.07	0.00	0.04	0.26	0.22	0.01	0.00

MTw-2-B	* MPN/100 ml * TC	FC	TDS	B	Constituent(mg/l) Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
SAMPLES	12	12	11	8	9	8	9	8	9	6	6	9	9
MEAN	825.83	3.33	744.36	0.34	229.78	0.63	4.15	5.31	21.40	0.62	65.33	6.77	156.00
STD. DEV.	2526.36	7.45	73.99	0.07	17.95	0.42	2.47	2.31	18.37	0.53	11.43	1.89	24.21

MTw-2-B	Ca	Mg	Ba	Cd	Constituent(mg/l) Cr	Cu	Mo	Ni	Pb	Zn	As	Se
SAMPLES	6	9	7	6	8	9	8	8	9	8	8	8
MEAN	26.91	42.08	0.16	0.01	0.02	0.06	0.11	0.03	0.20	0.19	0.02	0.01
STD. DEV.	7.28	15.63	0.09	0.01	0.02	0.05	0.03	0.02	0.24	0.19	0.01	0.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($) / PAGE 1 7/6/78

	TC	FC	TDS	B	Cl	F	NO3	TN	TOC	PO4	SO4	K	Na
H-TEST	$75	$75	99.00	99.00	99.00	$75	99.00	99.00	77.00	91.00	95.00	91.00	99.00
CHI-SQUARE	99.00	$80	99.00	95.00	99.00	99.00	99.00	99.00	$80	99.00	$80	99.00	99.00
T-TEST	$80	$80	99.00	99.00	99.00	$80	95.00	99.00	$80	$80	80.00	80.00	99.00

*LEVELS OF CONFIDENCE OF DIFFERENCE ($) / PAGE 2 7/6/78

	Ca	Mn	Ba	Cd	Cr	Cu	Mo	Ni	Pb	Zn	As	Se
H-TEST	99.00	99.00	$75	$75	$75	$75	$75	$75	$75	$75	$75	
CHI-SQUARE	99.00	90.00	$80	$80	80.00	95.00	99.00	99.00	$80	$80	90.00	
T-TEST	99.00	99.00	$80	$80	$80	$80	$80	$80	$80	$80	$80	

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APPENDIX F

GRAPHIC EVALUATION OF THE WATER ANALYSES

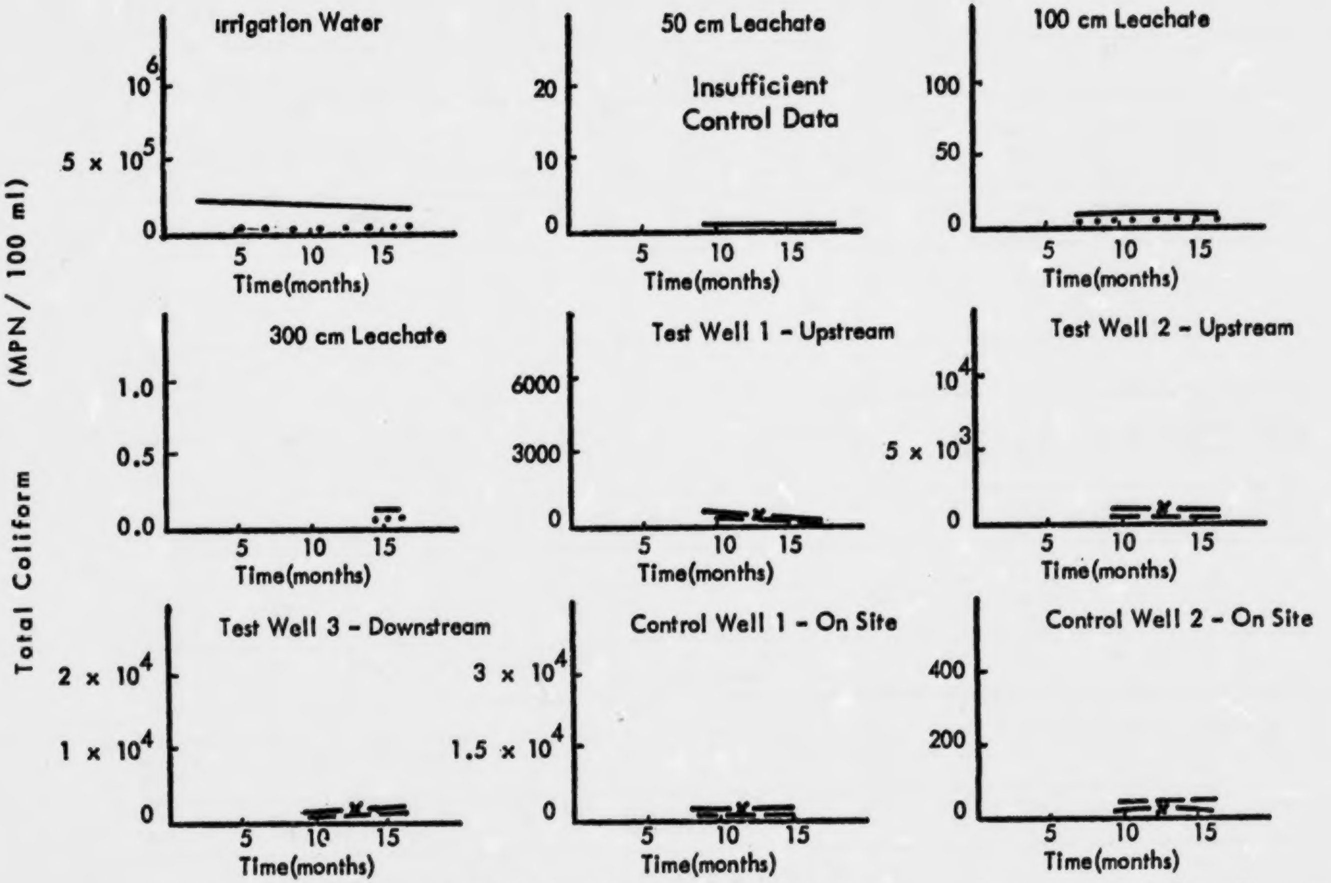

Figure F-1 . Test and control site total coliform analyses in irrigation, leachate, and well water.

Test ———, (t) Control . . . . . , (c)
Upper— — — Lower —x—

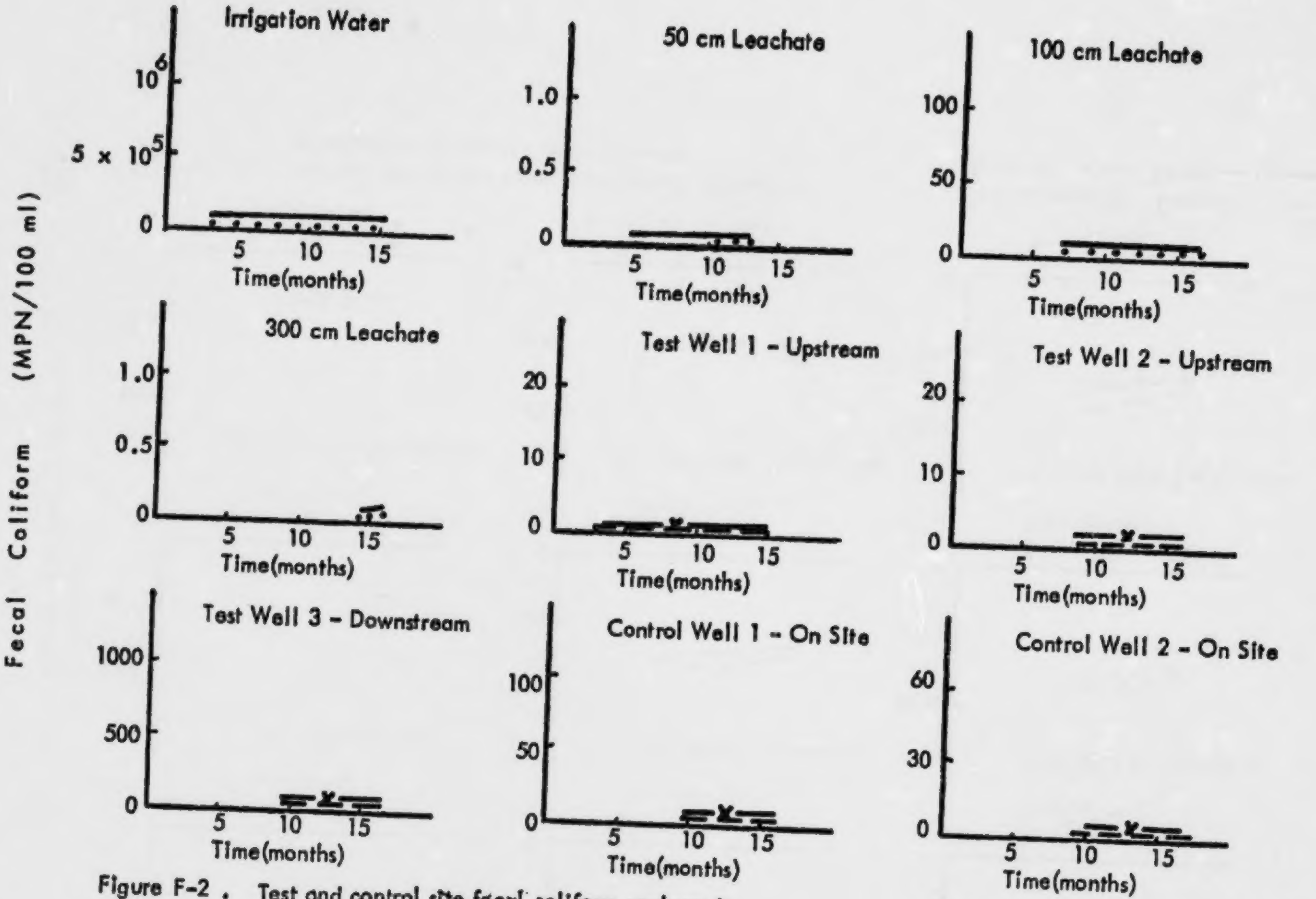

Figure F-2 . Test and control site fecal coliform analyses in irrigation, leachate, and well water.

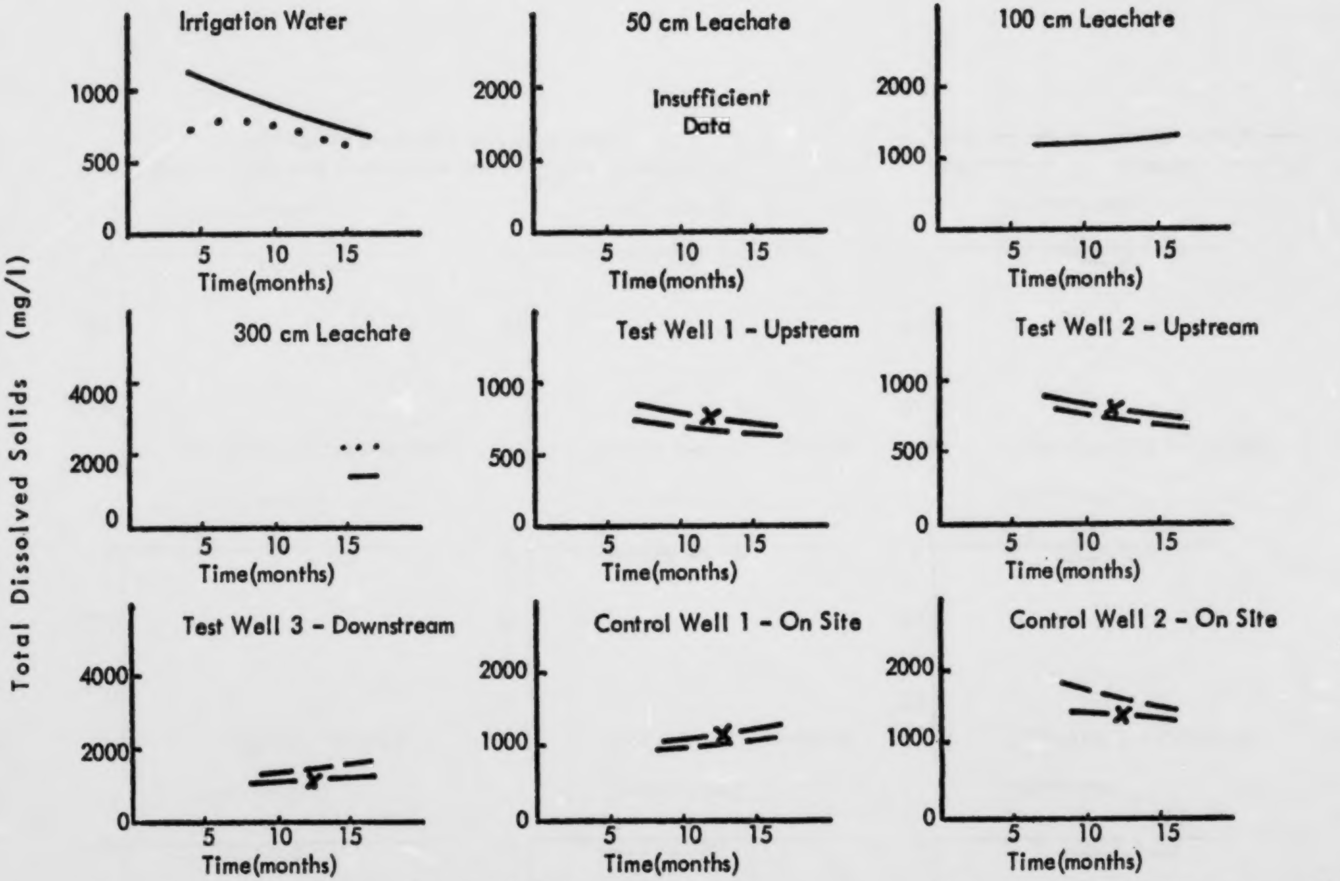

Figure F-3 . Test and control site total dissolved solids analyses in irrigation, leachate, and well water.

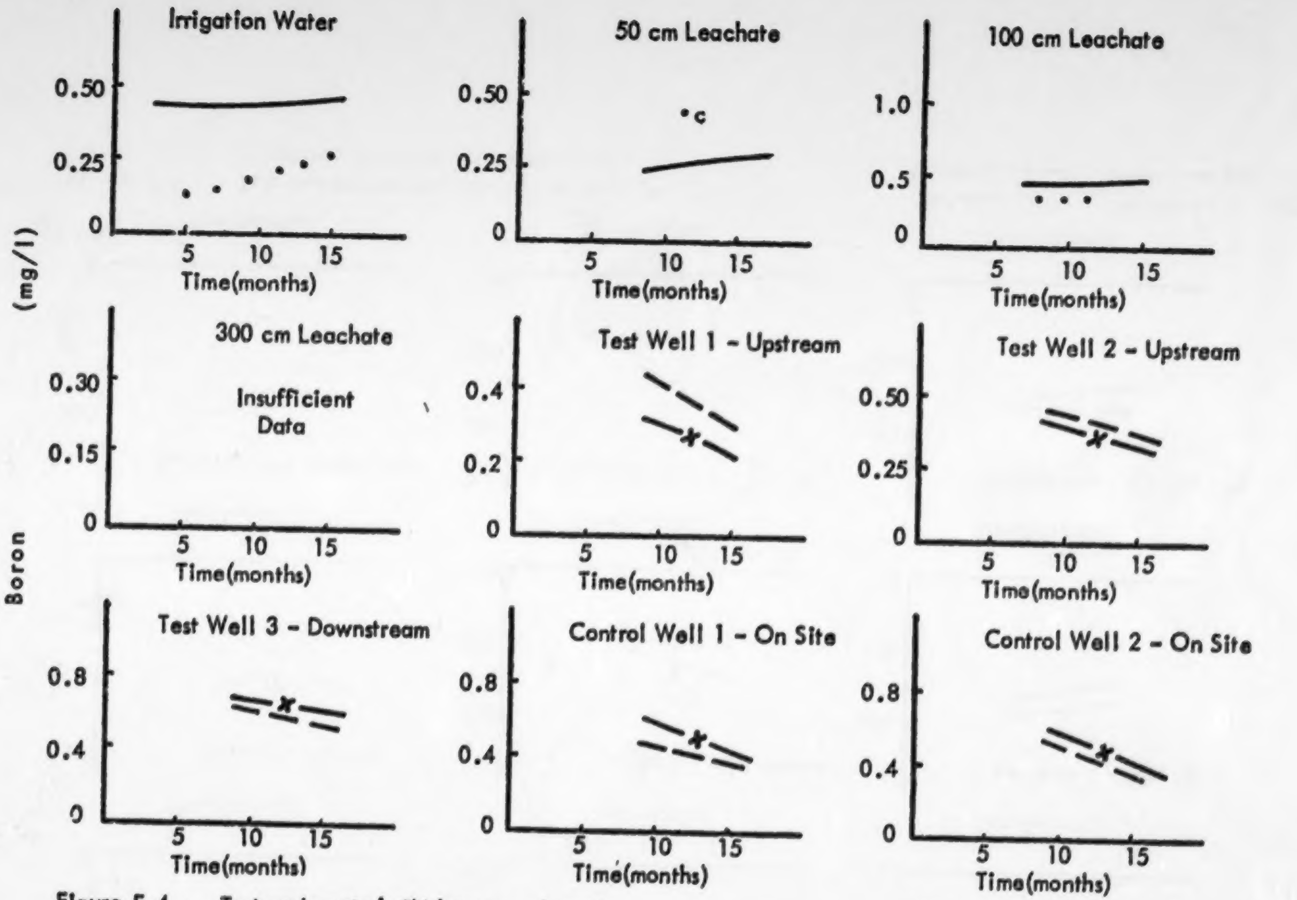

Figure F-4 . Test and control site boron analyses in irrigation, leachate, and well water.

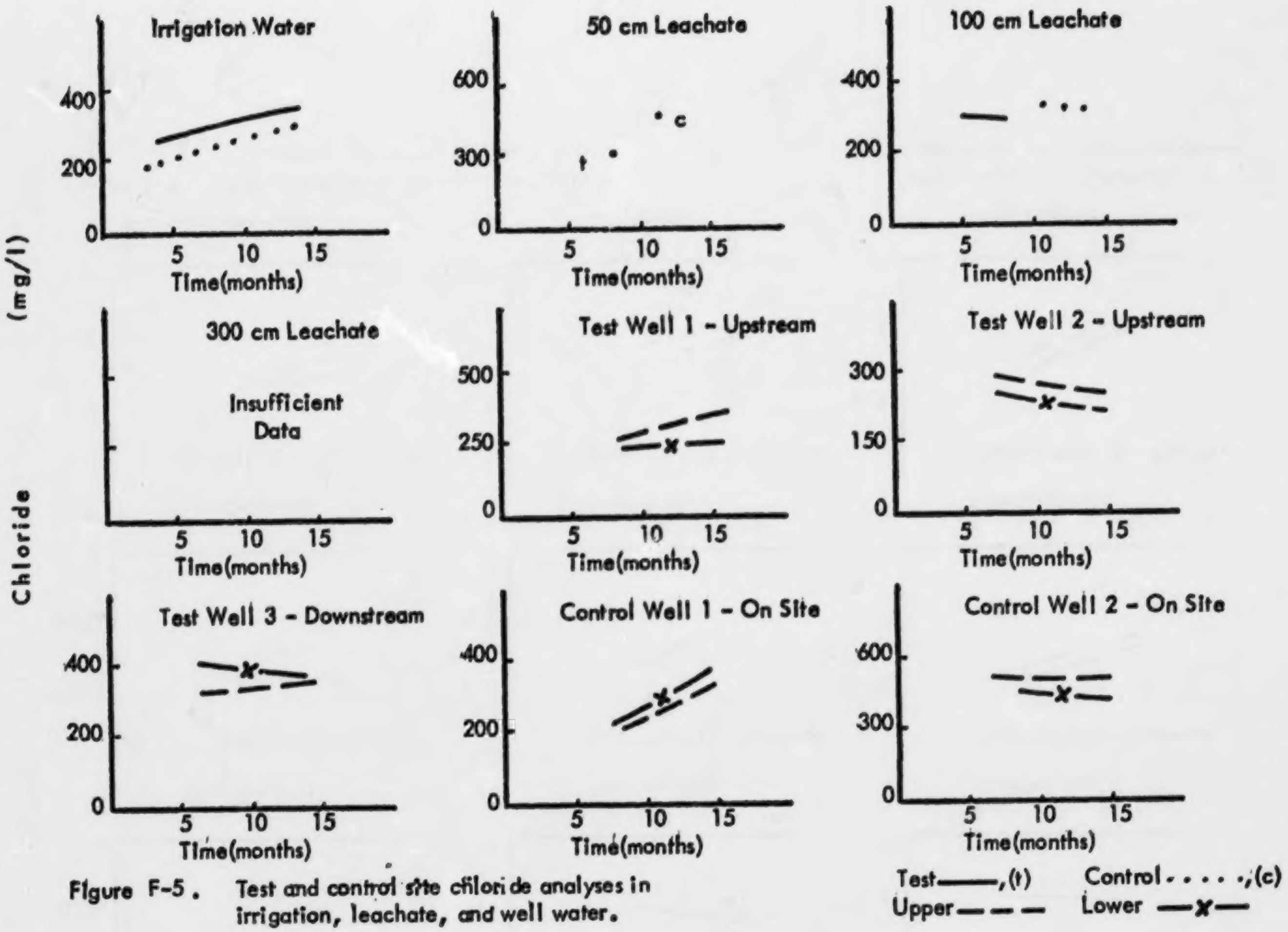

Figure F-5. Test and control site chloride analyses in irrigation, leachate, and well water.

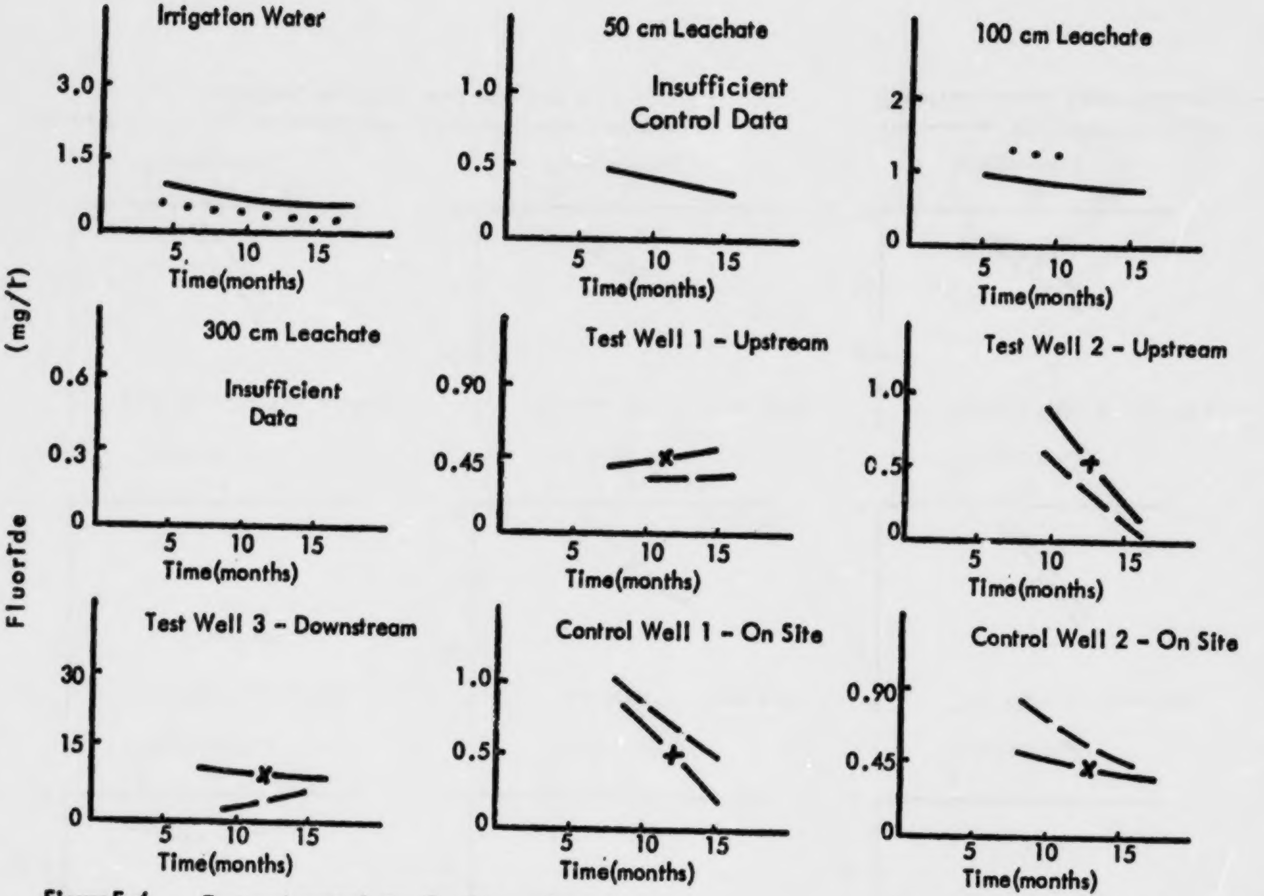

Figure F-6 . Test and control site fluoride analyses in irrigation, leachate, and well water.

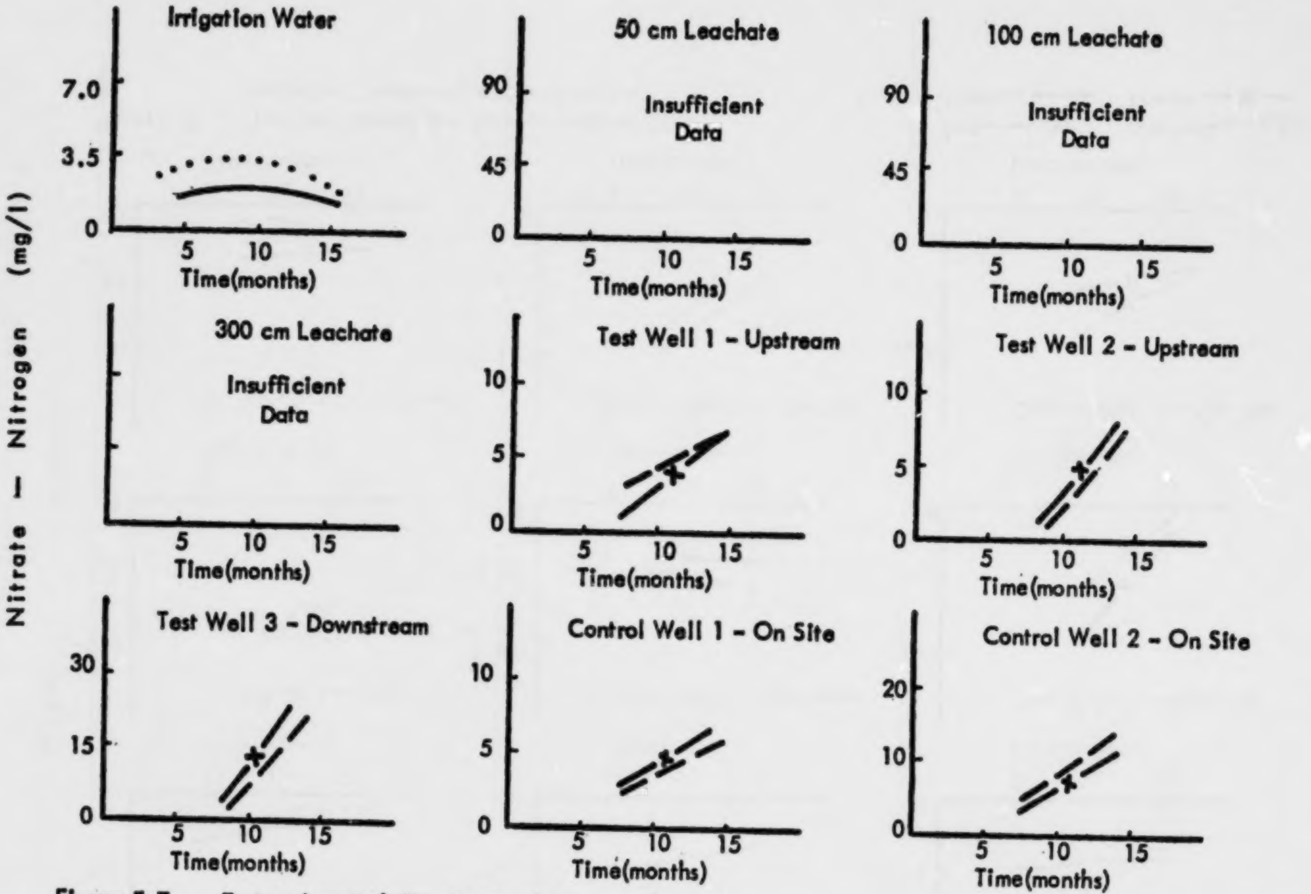

Figure F-7 Test and control site nitrate-nitrogen analyses in irrigation, leachate, and well water.

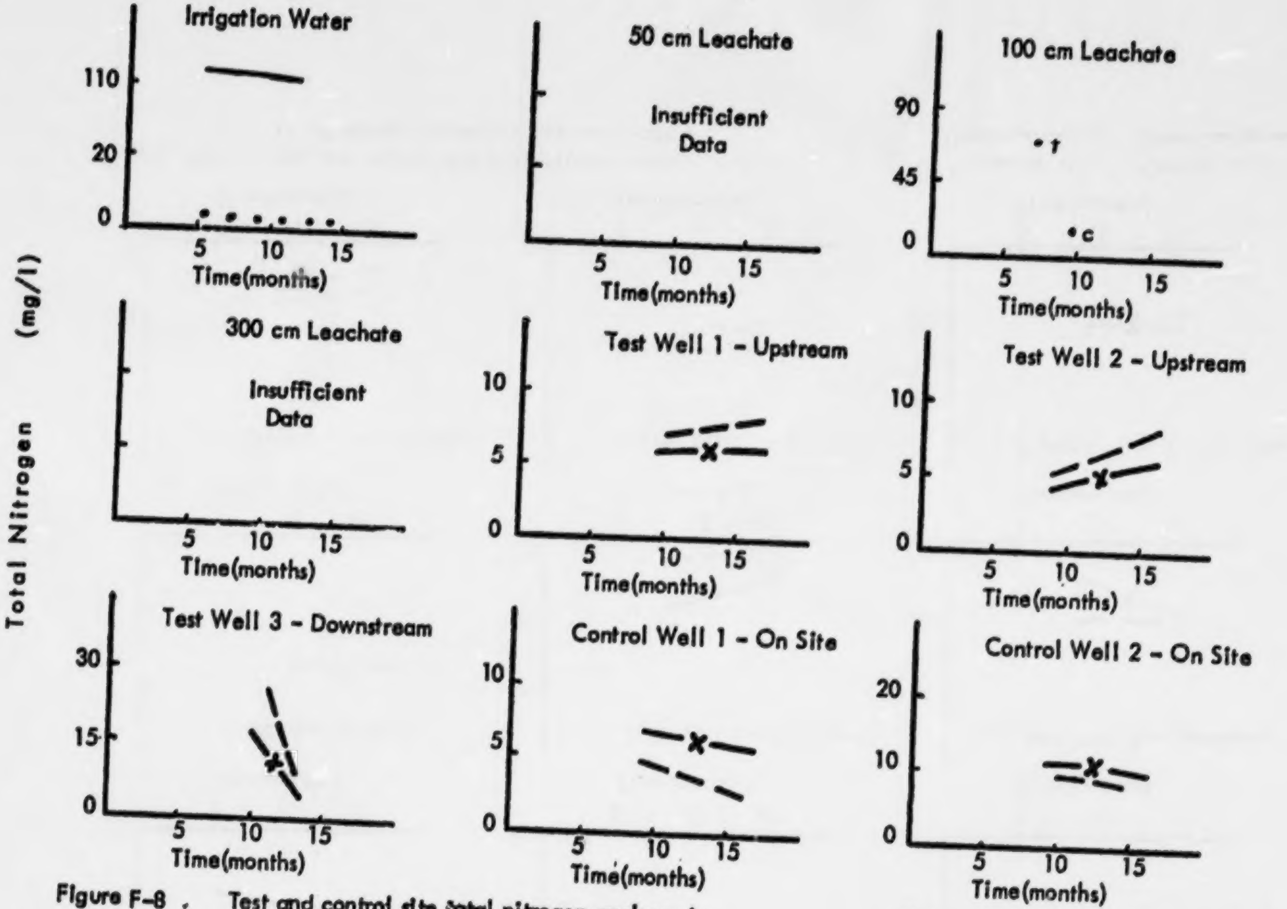

Figure F-8 . Test and control site total nitrogen analyses in irrigation, leachate, and well water.

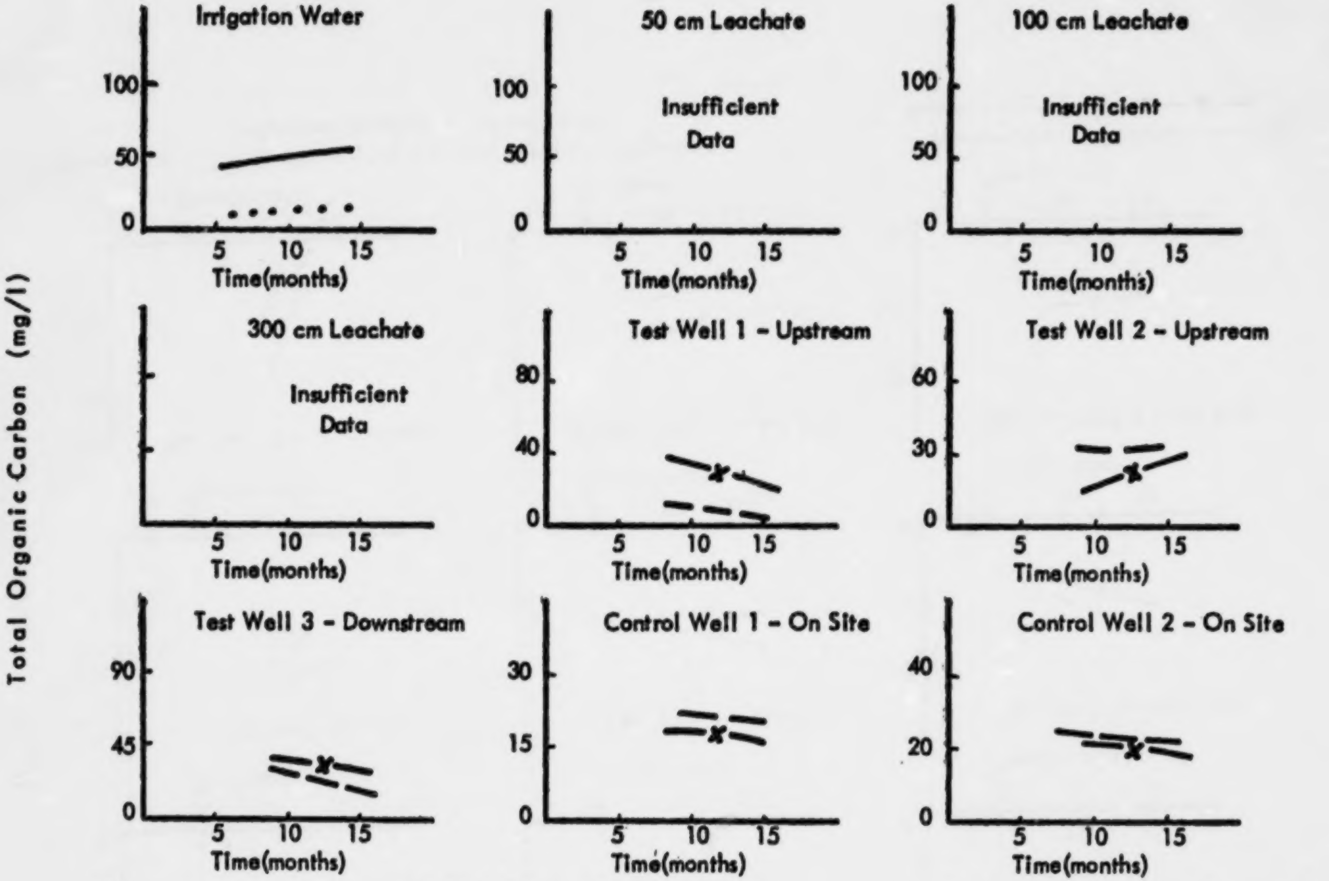

Figure F-9. Test and control site total organic carbon analyses in irrigation, leachate, and well water.

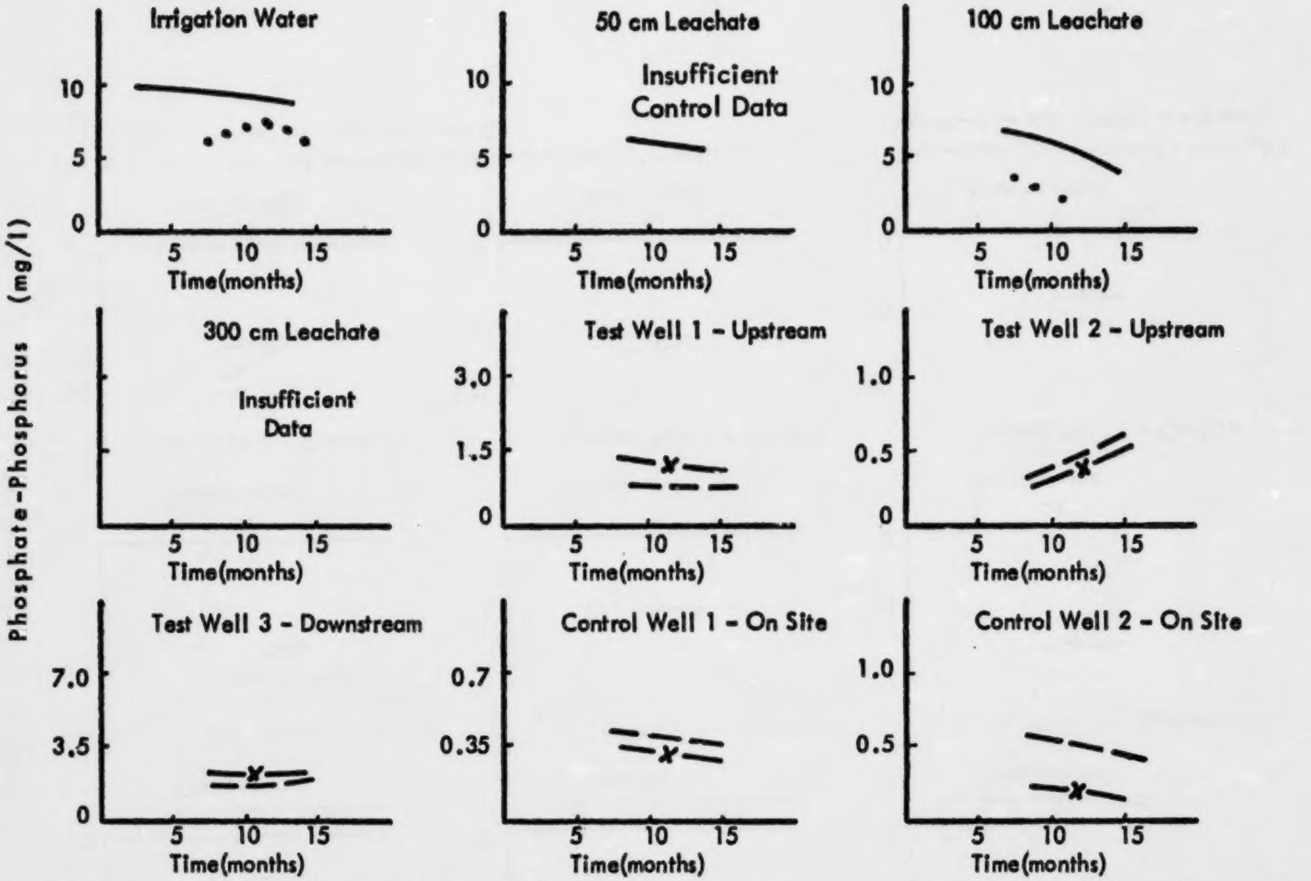

Figure F-10. Test and control site phosphate-phosphorus analyses in irrigation, leachate, and well water.

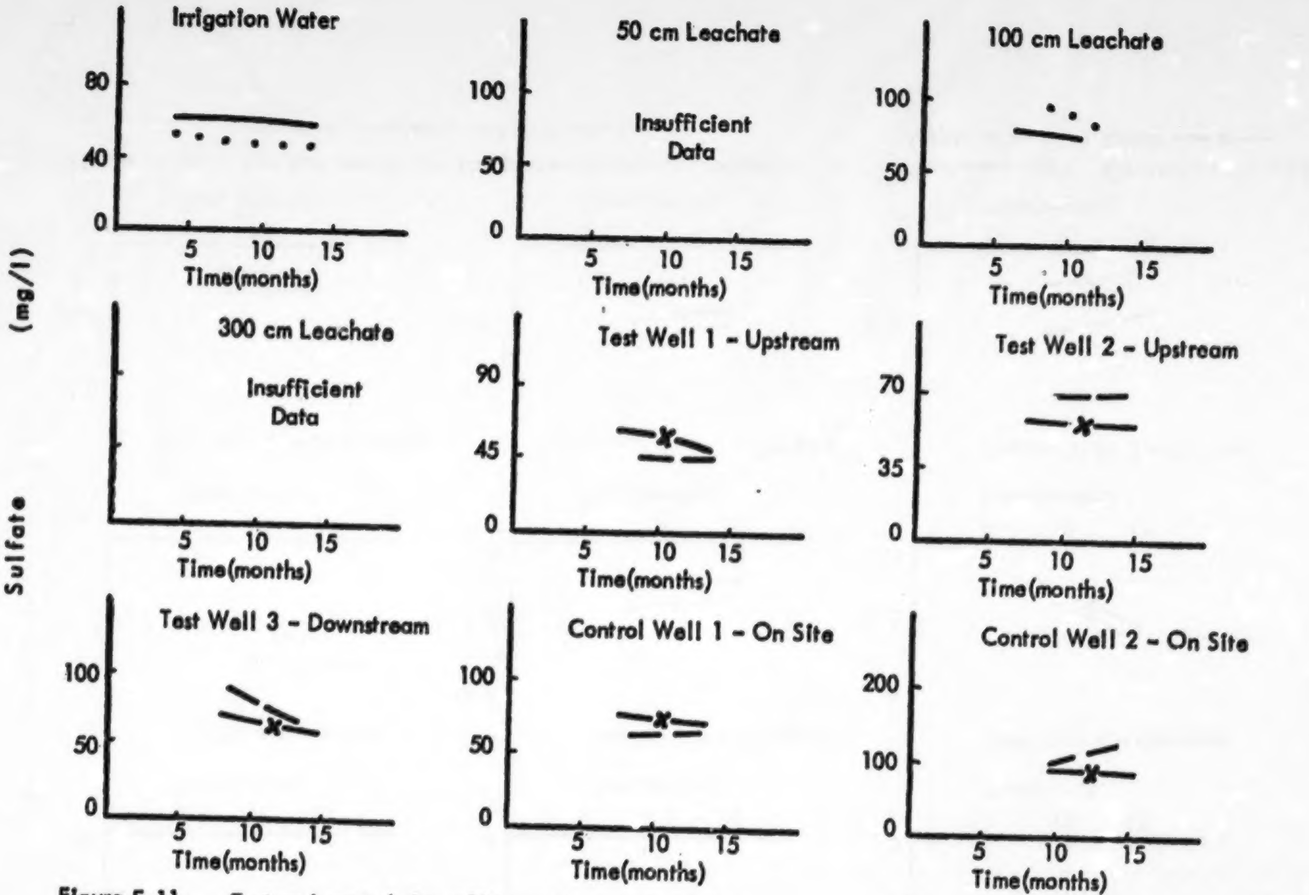

Figure F-11. Test and control site sulfate analyses in irrigation, leachate, and well water.

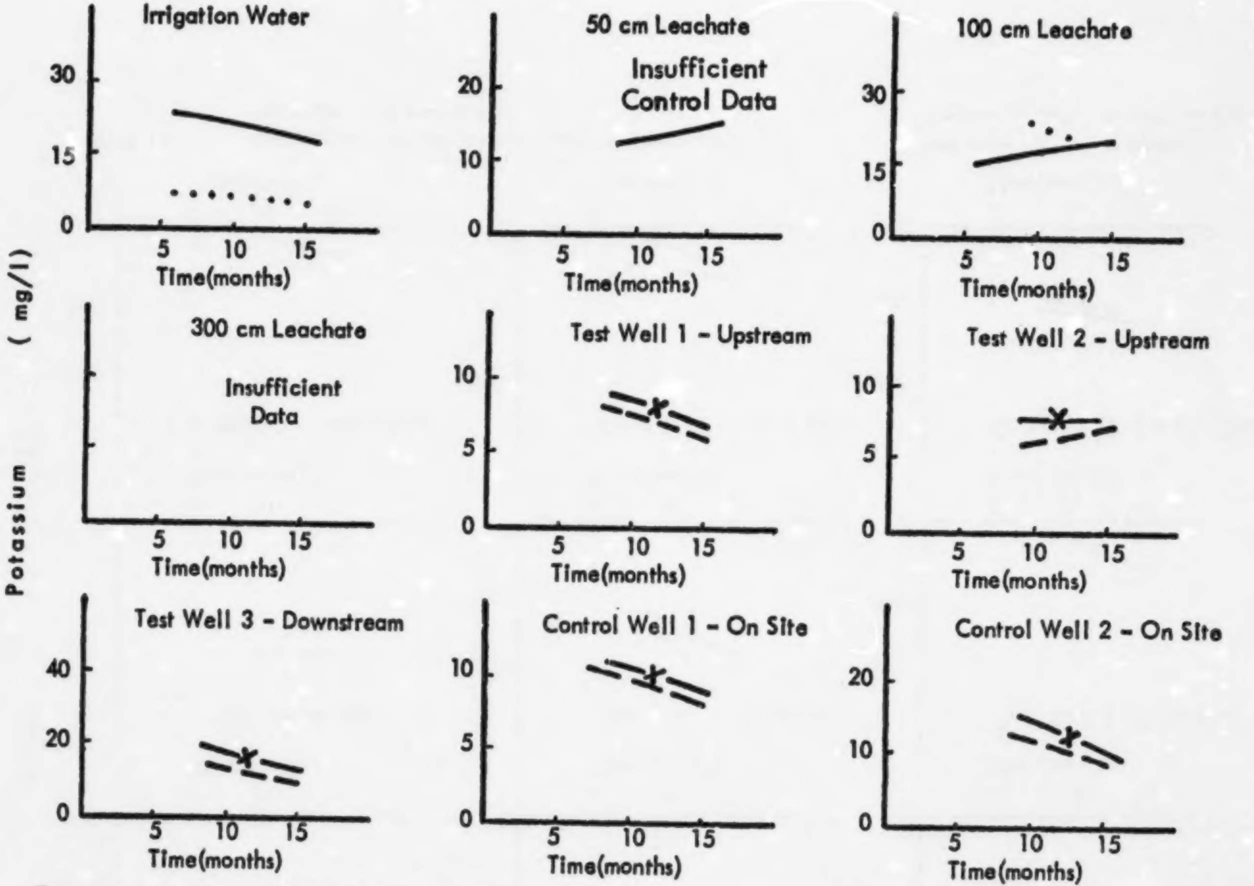

Figure F-12. Test and control site potassium analyses in irrigation, leachate, and well water.

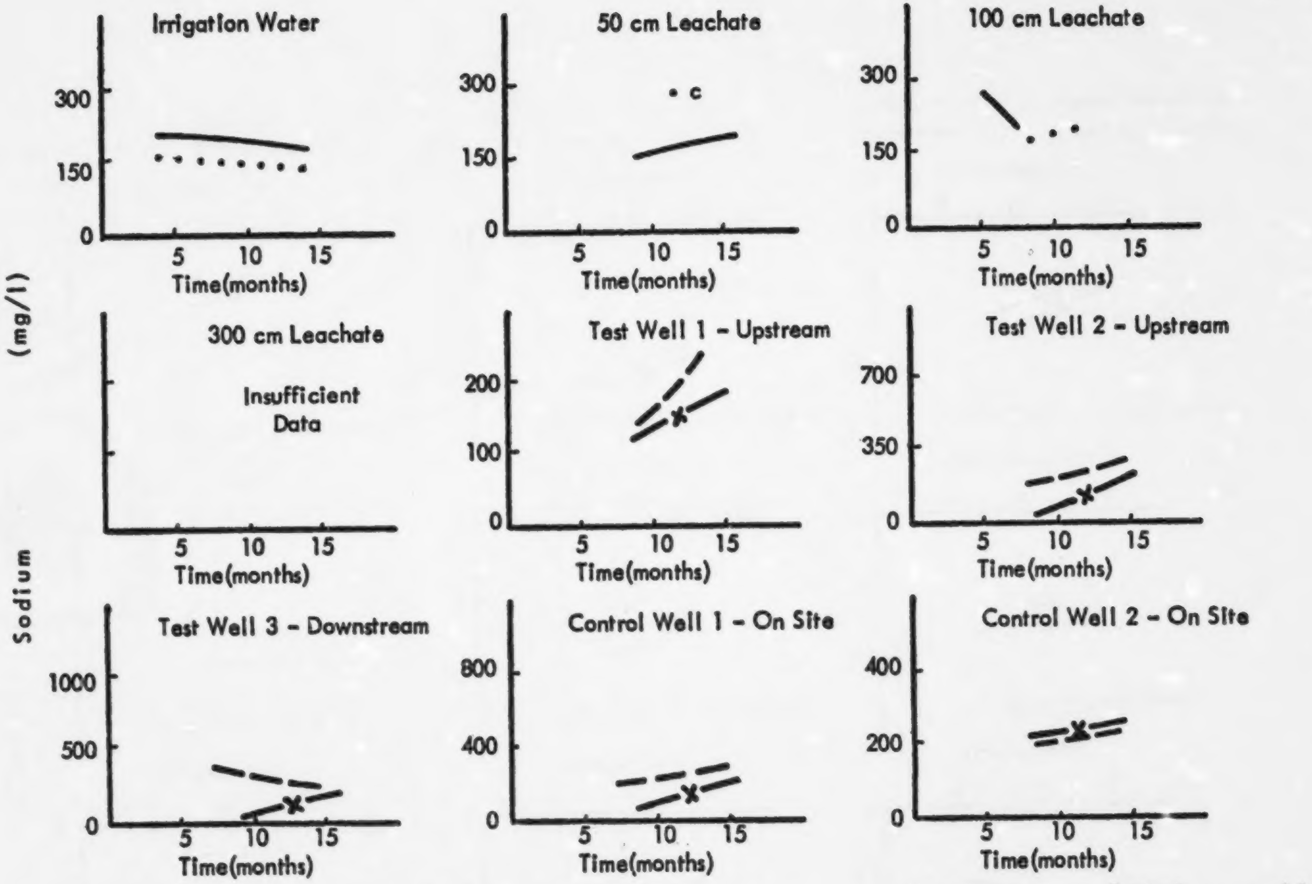

Figure F-13. Test and control site sodium analyses in irrigation, leachate, and well water.

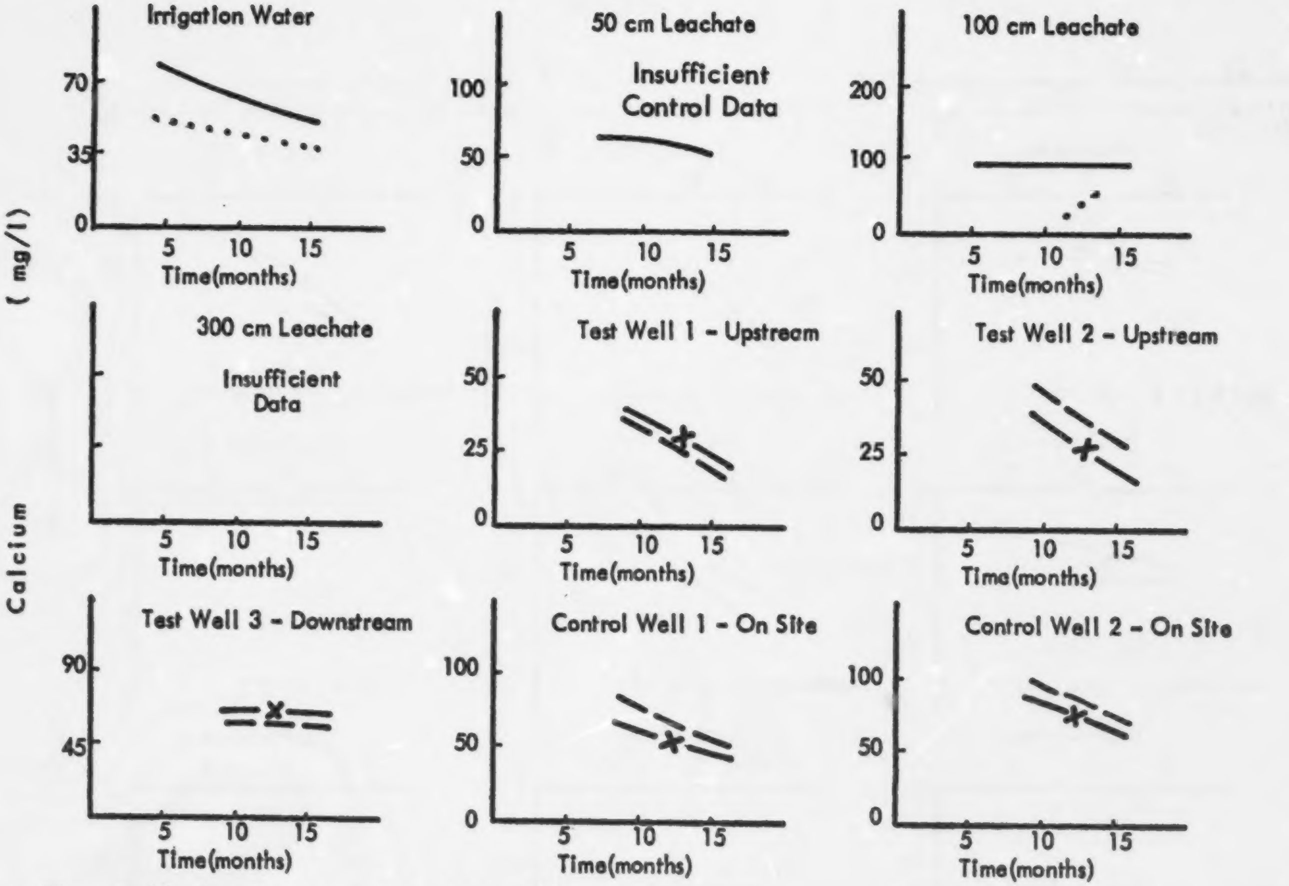

Figure F-14. Test and control site calcium analyses in irrigation, leachate, and well water.

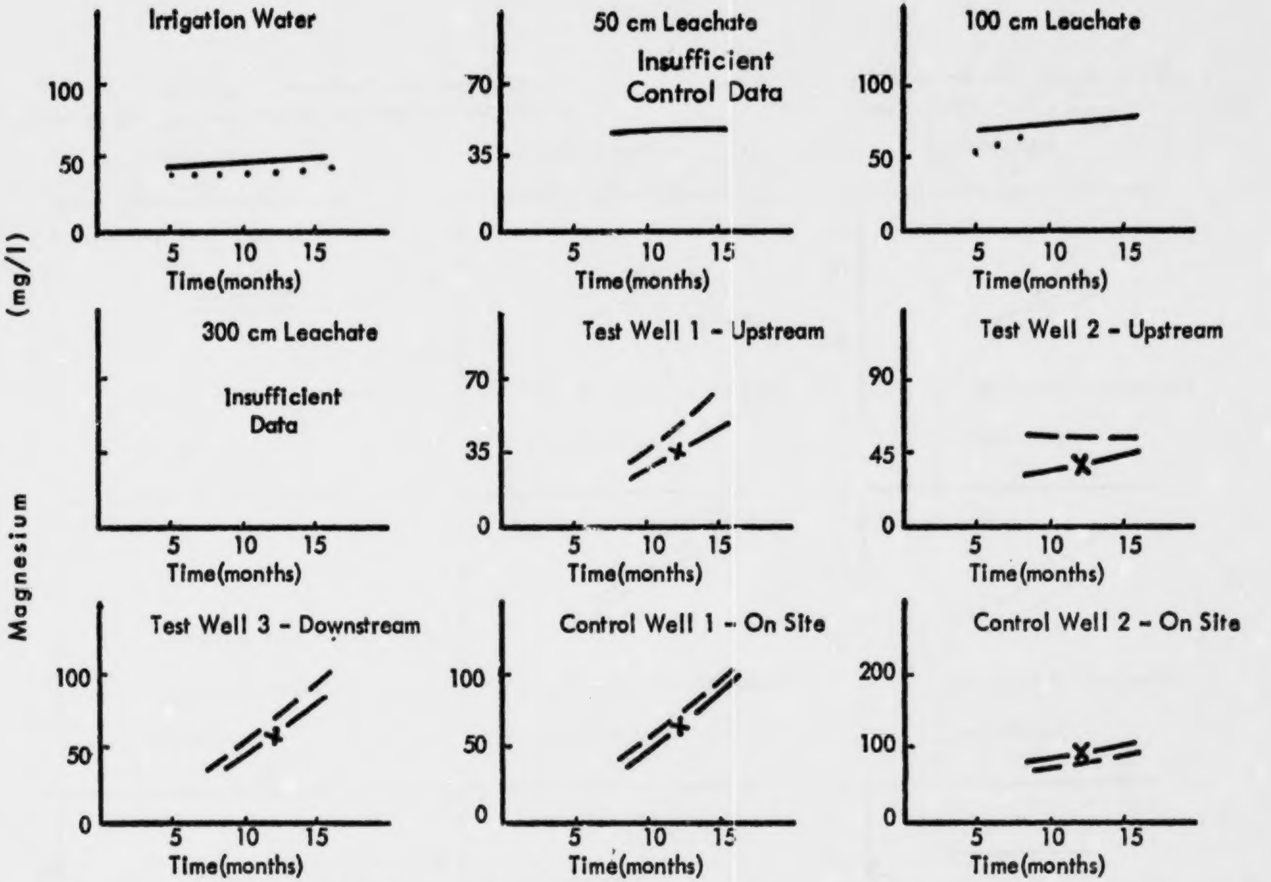

Figure F-15. Test and control site magnesium analyses in irrigation, leachate, and well water.

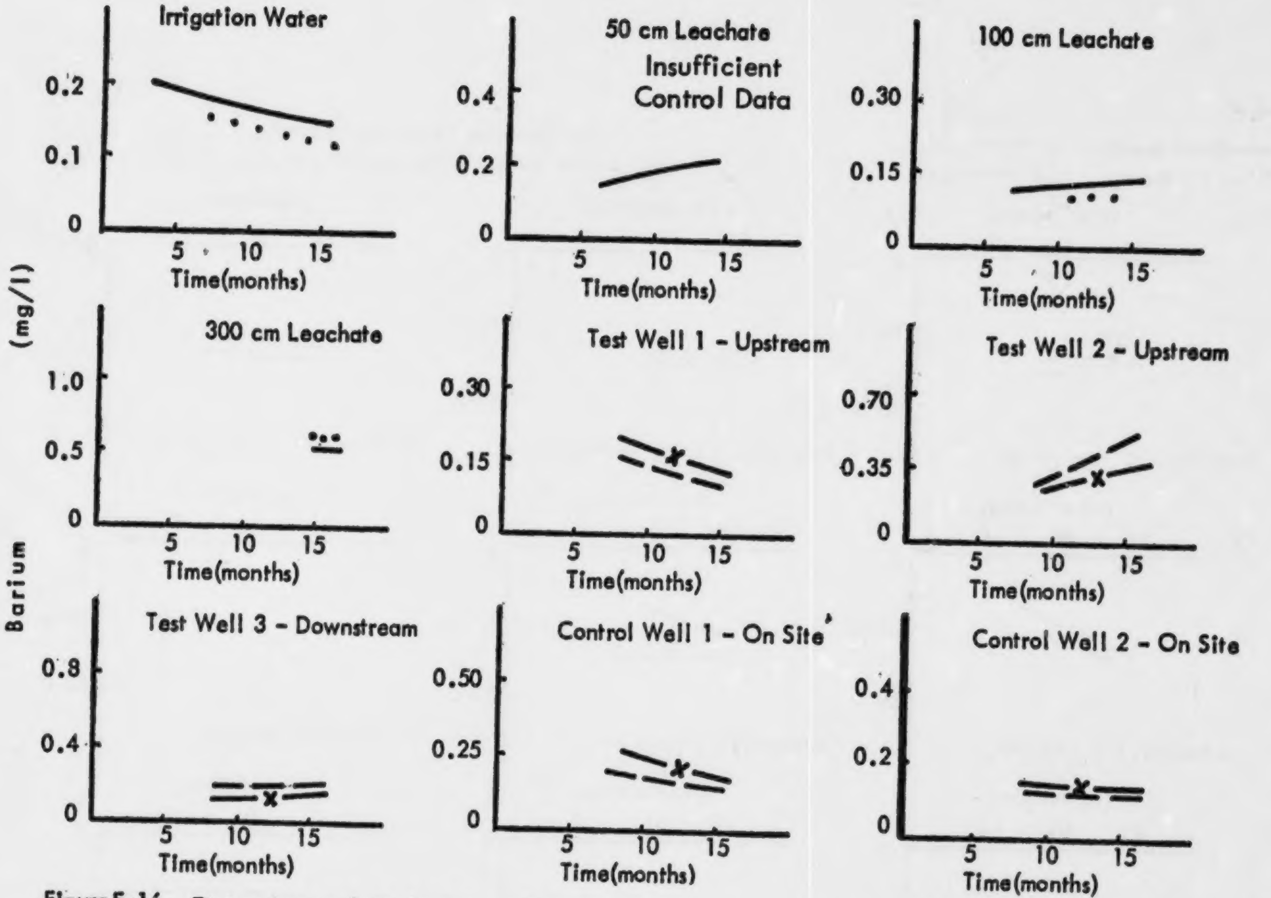

Figure F-16. Test and control site barium analyses in irrigation, leachate, and well water.

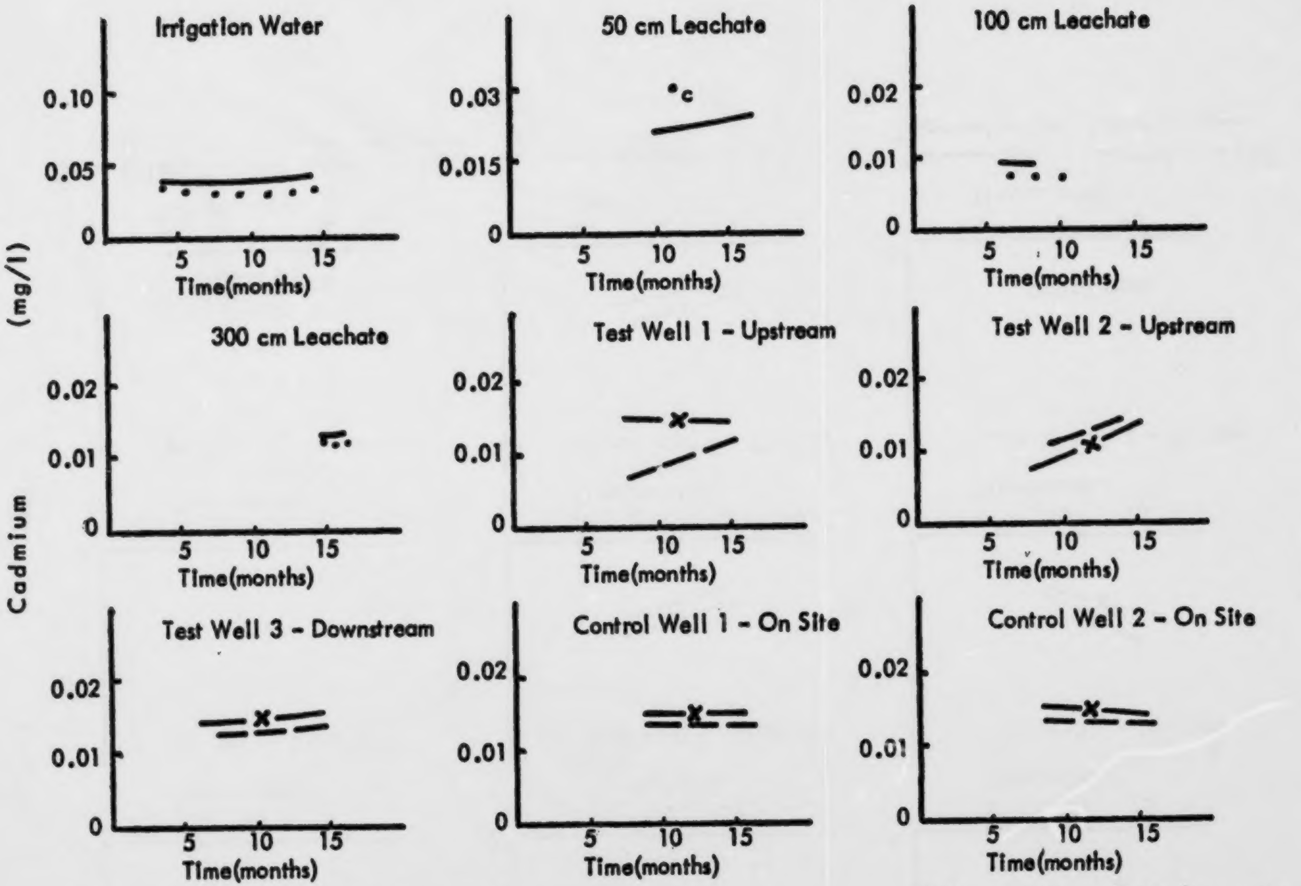

Figure F-17. Test and control site cadmium analyses in irrigation, leachate, and well water.

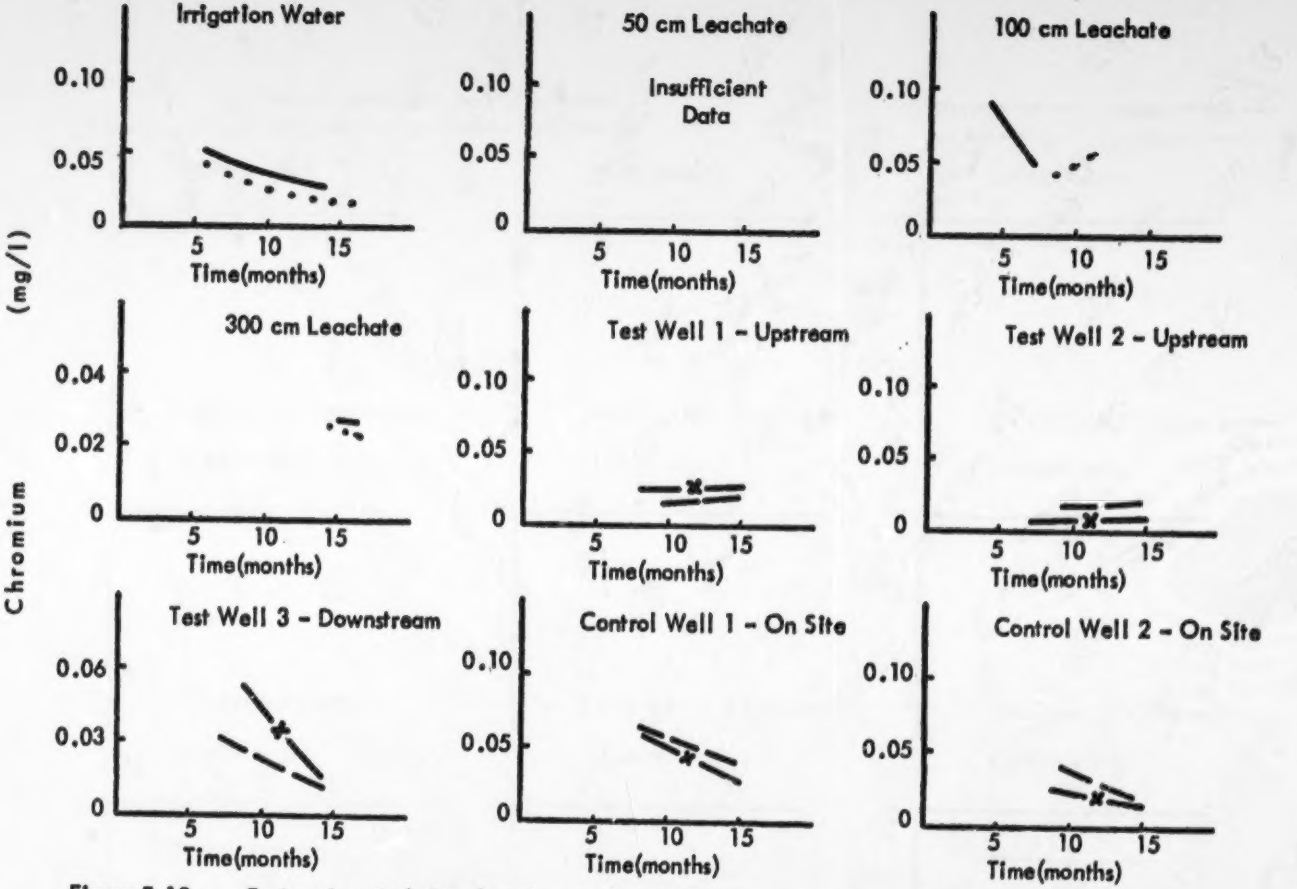

Figure F-18. Test and control site chromium analyses in irrigation, leachate, and well water.

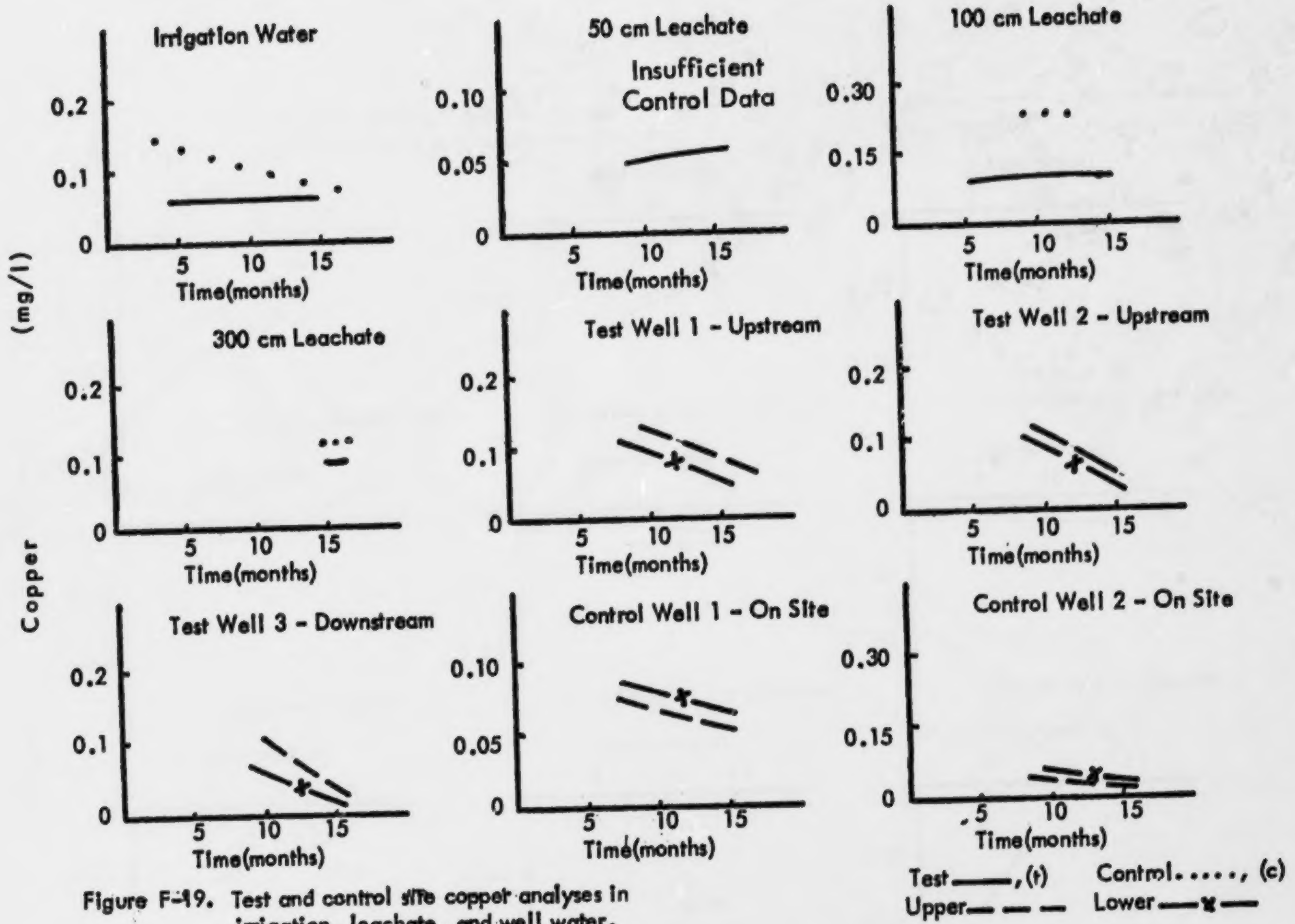

Figure F-19. Test and control site copper analyses in irrigation, leachate, and well water.

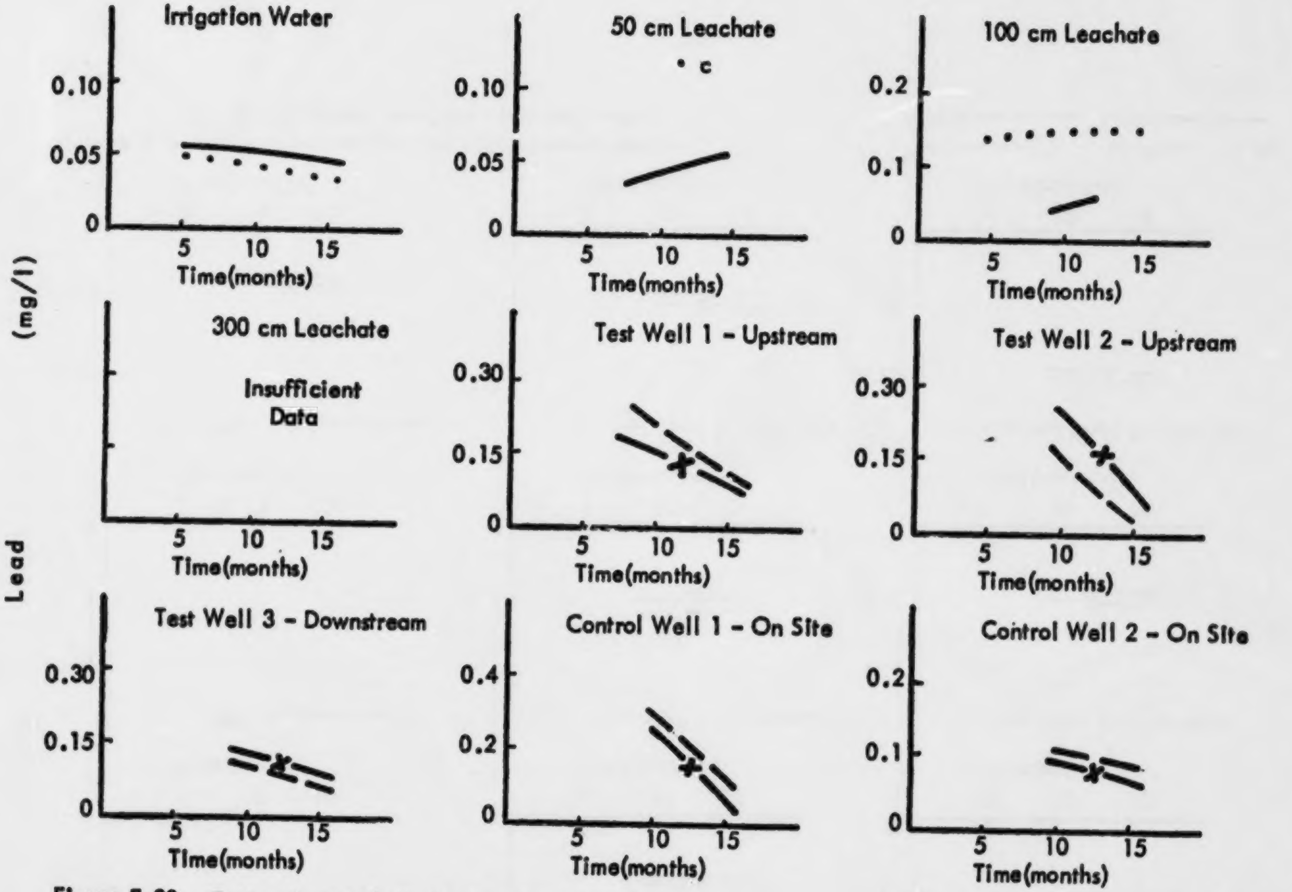

Figure F-20. Test and control site lead analyses in irrigation, leachate and well water.

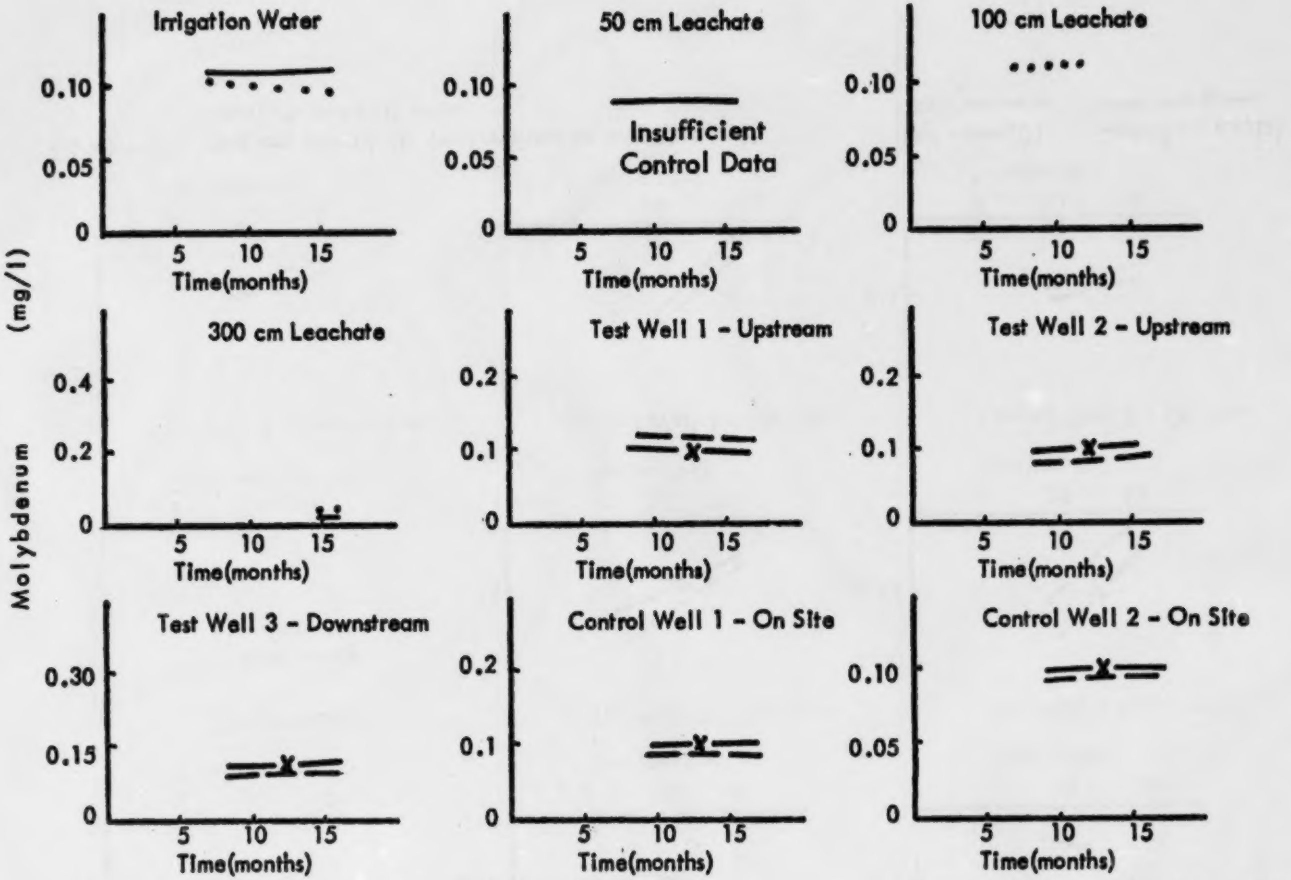

Figure F-21. Test and control site molybdenum analyses in irrigation, leachate, and well water.

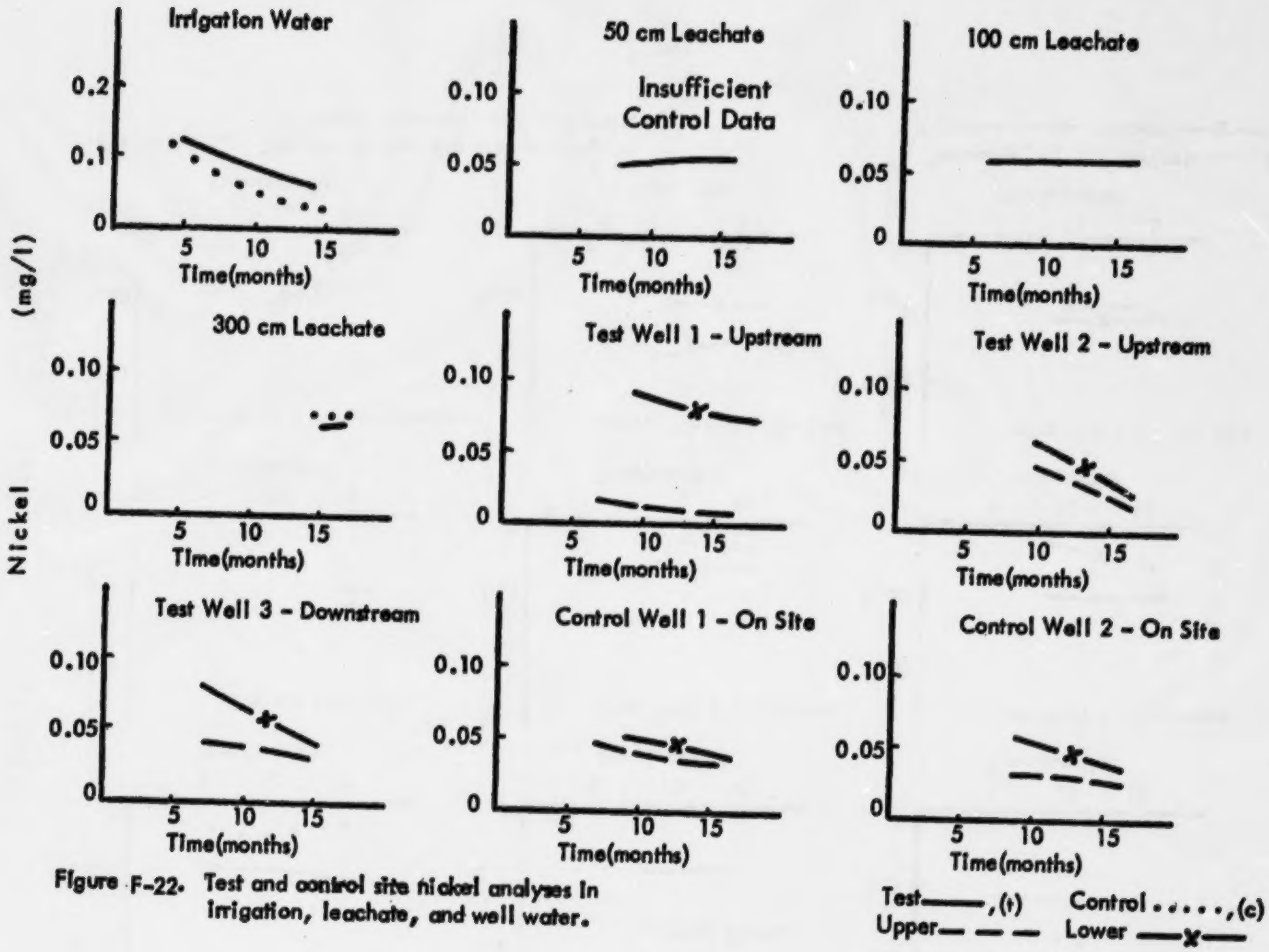

Figure F-22. Test and control site nickel analyses in irrigation, leachate, and well water.

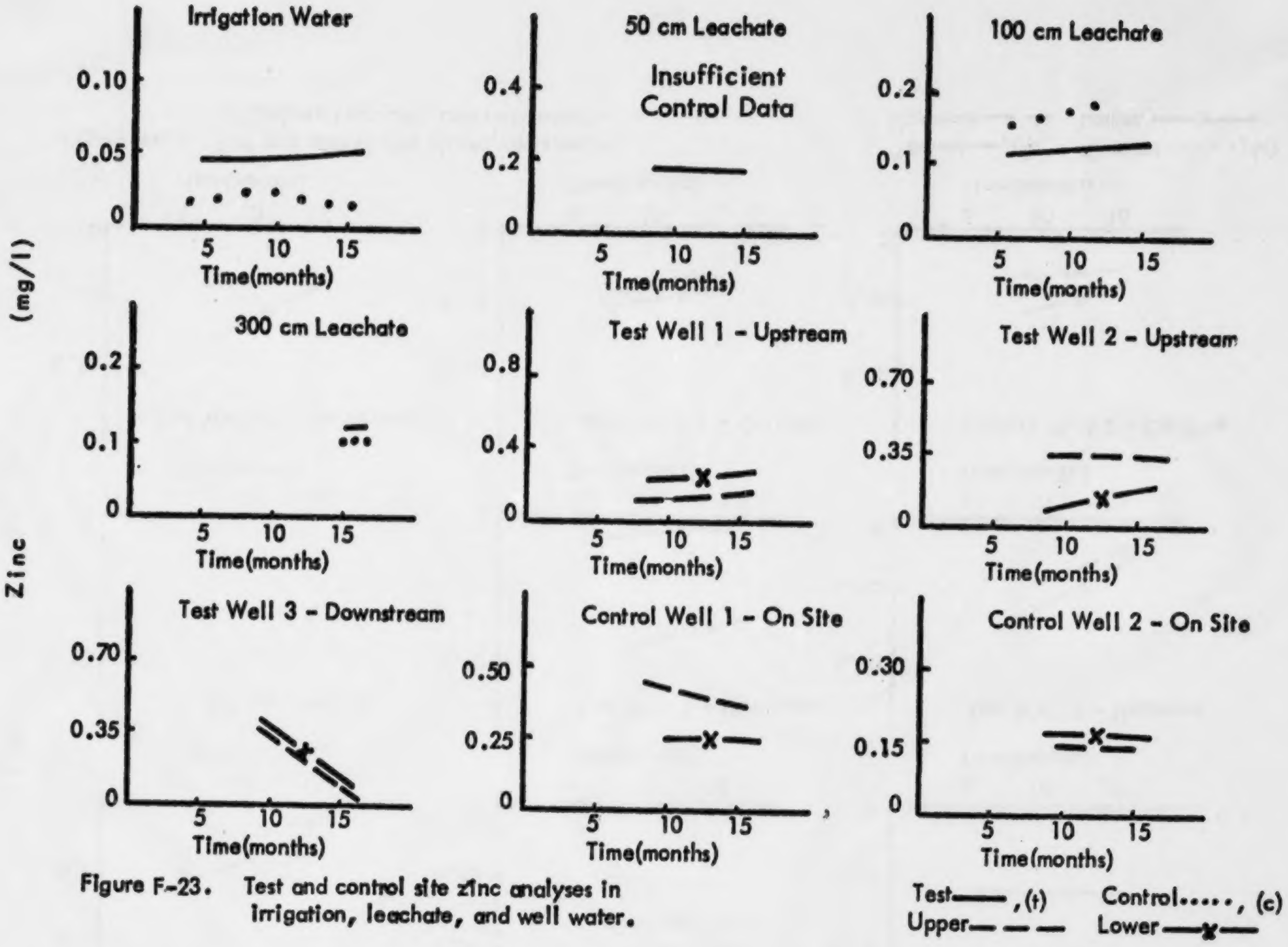

Figure F-23. Test and control site zinc analyses in irrigation, leachate, and well water.

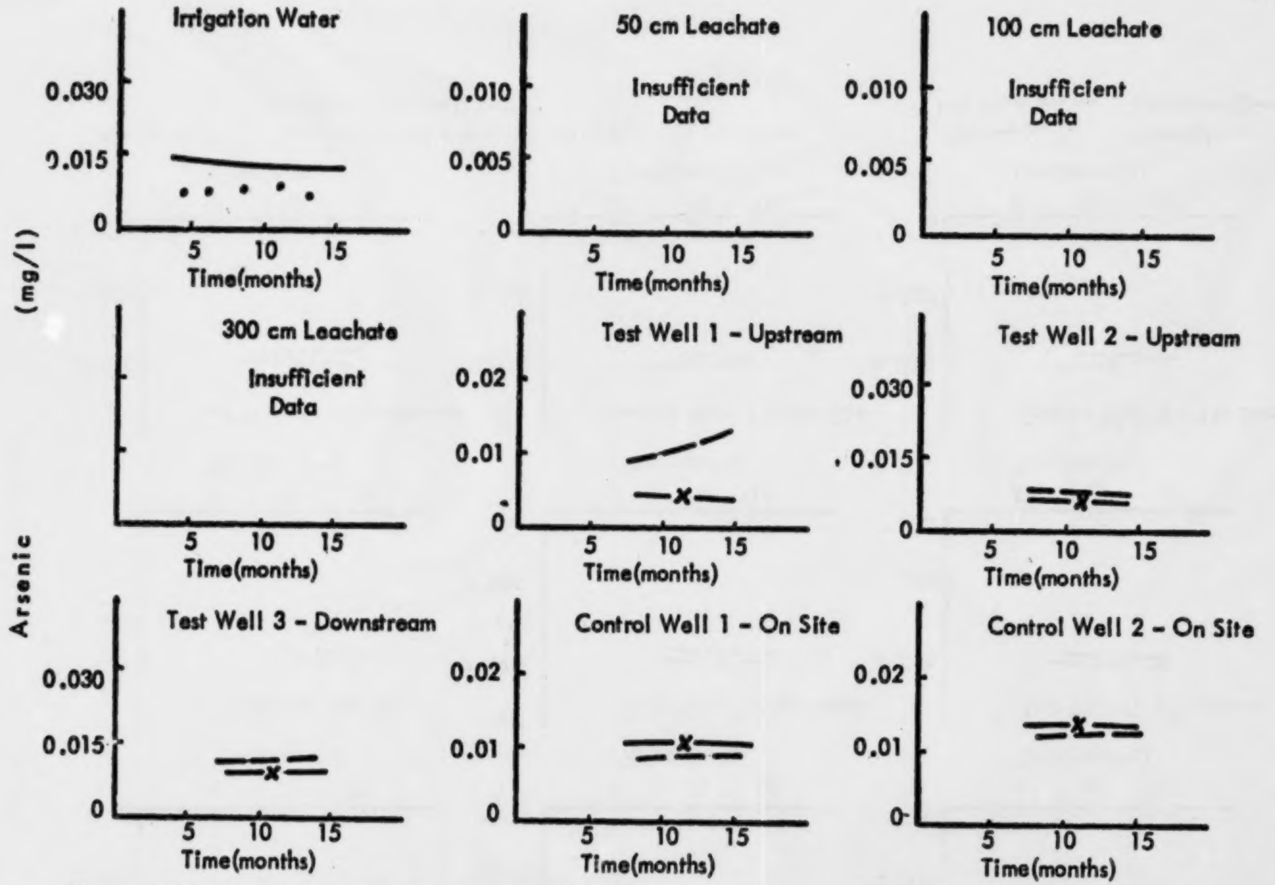

Figure F-24 Test and control site arsenic analyses in irrigation, leachate, and well water.

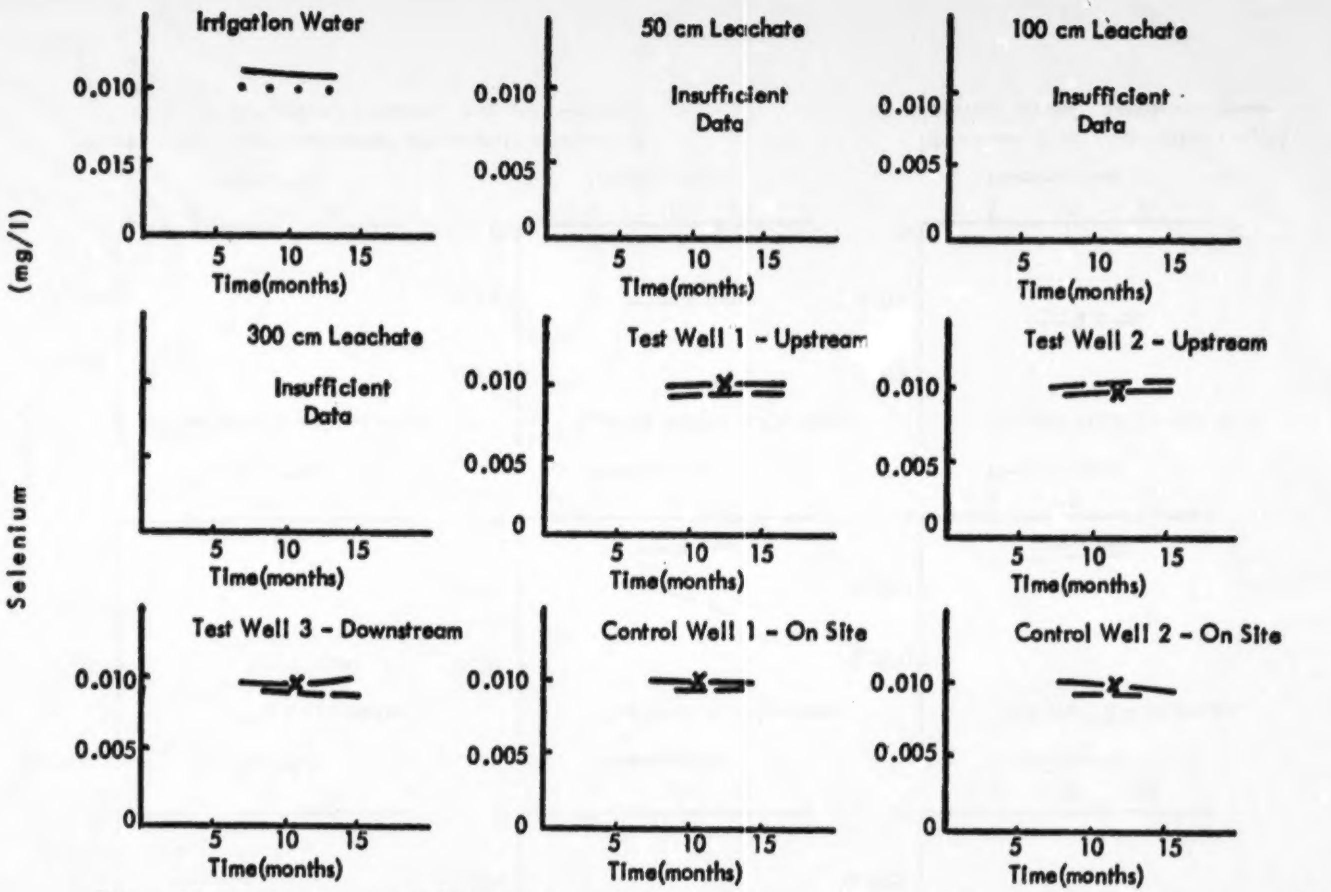

Figure F-25. Test and control site selenium analyses in irrigation, leachate, and well water.

Test——,(t) Control.....,(c)
Upper— — — Lower—x—

APPENDIX G

AGRICULTURAL BALANCE TABLES

TABLE G-1. TEST SITE WATER BALANCE, 1965-1978

		Precipitation			Irrigation				
Item	Year 19___ A	Total (cm) B	Effective[a] (cm) C	Total (1000 cu m) D	Total[b] (cm) E	Effective[a] (cm) F	Total Effective Water (cm) G[e]	Average Evapo-transpira-tions (cm)[d] H	Average Leachate (cm) I[f]
	78[g]	4	8	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	77	14	13	125	403	330	343	129	214
	76	25	23	138	445	365	388	129	259
	75	17	15	205	660	541	556	129	427
	74	28	25	147	474	389	414	129	285
	73	16	14	117	379	311	325	129	196
	72	20	18	186	601	493	511	129	382
	71	13	12	214	690	566	578	129	449
	70	19	17	258	831	682	699	129	570
	69	18	16	266	858	704	720	129	591
	68	17	15	247	798	653	668	129	539
	67	21	19	215	694	569	588	129	459
	66	28	25	187	603	495	520	129	391
	65	25	23	148	477	429	452	129	323
Total		261	235	2,453	7,913	6,527	6,762	1,677	5,085
Avg.		20	18	189	609	502	520	129	391
Area: 3.1 ha									

[a] Runoff coefficient is percent of precipitation lost through runoff. Runoff coefficient: 0.1.

[b] Estimating that 8000 m^3 per day of the treated effluent is diverted by percolation, evaporation, loss, etc.

[c] Irrigation efficiency is percent of total applied which is not lost to runoff. Irrigation efficiency = 82% (estimated value).

[d] Source: [33]

[e] G = C + F.

[f] I = G - H.

[g] January only (not included in averages).

Note: All numbers rounded off to nearest whole number.

TABLE G-2. CONTROL SITE WATER BALANCE, 1965-1978

Item	Year 19__ A	Precipitation Total (cm) B	Precipitation Effective[a] (cm) C	Total (1000 cu m) D	Irrigation Total[b] (cm) E	Irrigation Effective[c] (cm) F	Total Effective Water (cm) G[e]	Average Evapo-transpira-tions (cm)[d] H	Average Leachate (cm) I[f]
78[g]		4	4						
77		14	13	198	157	154	167	119	48
76		25	23	317	253	247	270	119	151
75		17	15	191	152	149	164	119	45
74		28	25	191	152	149	174	119	55
73		16	14	210	168	164	178	119	59
72		20	18	344	274	268	286	119	167
71		13	12	191	152	149	161	119	42
70		19	17	210	168	164	181	119	62
69		18	16	191	152	149	165	119	46
68		17	15	191	152	149	164	119	45
67		21	19	191	152	149	168	119	49
66		28	25	191	152	149	174	119	55
65		25	23	191	152	149	172	119	53
Total		261	.235	2,807	2,232	2,189	2,424	1,547	877
Avg.		20	18	216	172	168	186	119	67
Area:	12.6 ha								

[a] Runoff coefficient is percent of precipitation lost through runoff. Runoff coefficient = 0.1.

[b] Estimated values.

[c] Irrigation efficiency is percent of total applied which is not lost to runoff. Irrigation efficiency = 98%.

[d] Source: 33

[e] G = C+F.

[f] I = G - H.

[g] January only (not included in averages).

Note: All numbers are rounded off to nearest whole number.

TABLE G-3. TEST SITE ESTIMATED ANNUAL TOTAL WATER USED AND NUTRIENT SUPPLIED IN THE IRRIGATION WATER 1965-1978

Item	Year 19__	Precipitation[a]		Irrigation[b]		Total Water		Fertilizer Value in Effluent Irrigation[c]								
		(cm/crop)[d]	(cm/yr.)	(cm/crop)[d]	(cm/yr)	(cm/crop)[d]	(cm/yr)	(mg/l)			(kg/ha/crop)[d]			(kg/ha/yr)		
								N	P	K	N	P	K	N	P	K
	A	B	C	D	E	F[f]	G[g]		H			I[h]			J[i]	
	78[e]		4													
	77	7	14	201	403	209	417	25	10	20	503	201	403	1,007	403	806
	76	13	25	223	445	235	470	25	10	20	557	223	445	1,113	445	890
	75	9	17	330	660	339	677	25	10	20	825	330	660	1,650	660	1,320
	74	14	28	237	474	251	502	25	10	20	593	237	474	1,185	474	948
	73	8	16	189	379	197	395	25	10	20	473	189	379	947	379	758
	72	10	20	301	601	311	621	25	10	20	751	301	601	1,503	601	1,202
	71	7	13	345	690	351	703	25	10	20	863	345	690	1,725	690	1,380
	70	9	19	415	831	425	850	25	10	20	1,039	415	831	2,077	831	1,662
	69	9	18	429	858	438	876	25	10	20	1,073	429	858	2,145	858	1,716
	68	9	17	399	798	407	815	25	10	20	997	399	798	1,995	798	1,596
	67	11	21	347	694	357	715	25	10	20	867	347	694	1,735	694	1,388
	66	14	28	301	603	315	631	25	10	20	753	301	603	1,507	603	1,206
	65	13	25	239	477	251	502	25	10	20	597	239	477	1,193	477	954
Total		133	261	3,956	7,913	4,086	8,174				9,891	3,956	7,913	19,782	7,913	15,826
Avg.		10	20	304	609	314	629	25	10	20	761	304	609	1,522	609	1,217

[a] Weather data: Phoenix Airport 1965-70, Mesa sewage treatment plant 1971-78.

[b] Site farmer.

[c] Estimated to be same as existing irrigation water.

[d] Based on two crops/year.

[e] January only (not included in averages).

[f] F = B + D

[g] G = C + E

[h] I = D x H

[i] J = E x H

Note: All numbers rounded off to nearest whole number.

TABLE G-4. CONTROL SITE ESTIMATED ANNUAL TOTAL WATER USED AND NUTRIENT SUPPLIED IN IRRIGATION WATER 1965-1978

Item	Year 19___	Precipitation[a]		Irrigation[b]		Total Water		Fertilizer Value in Control Irrigation[c]								
		(cm/crop)[d]	(cm/yr.)	(cm/crop)[d]	(cm/yr)	(cm/crpp)[d]	(cm/yr)	(mg/l)			(kg/ha/crop)			(kg/ha/yr)		
	A	B	C	D	E	F[f]	G[g]	N	P H	K	N	P I[h]	K	N	P J[i]	K
	78[e]		4					5	.6	7						
	77	7	14	79	157	86	171	5	.6	7	39	5	55	79	9	110
	76	13	25	127	253	140	278	5	.6	7	63	8	84	127	15	177
	75	9	17	76	152	85	169	5	.6	7	38	5	53	76	9	106
	74	14	28	76	152	90	180	5	.6	7	38	5	53	76	9	106
	73	8	16	84	168	92	184	5	.6	7	42	5	59	84	10	118
	72	10	20	137	274	134	294	5	.6	7	17	7	87	137	16	192
	71	7	13	76	152	83	165	5	.6	7	38	5	53	76	9	106
	70	9	19	84	168	93	187	5	.6	7	42	5	59	84	10	118
	69	9	18	76	152	85	170	5	.6	7	38	5	53	76	9	106
	68	9	17	76	152	85	169	5	.6	7	38	5	53	76	9	106
	67	11	21	76	152	87	173	5	.6	7	31	4	43	76	7	85
	66	14	28	76	152	90	180	5	.6	7	38	5	53	76	9	106
	65	13	25	76	152	89	177	5	.6	7	38	5	53	76	9	106
Total		133	261	1,119	2,236	1,239	2,497				500	69	758	1,119	130	1,542
Avg.		10	20	86	172	95	192	5	.6	7	38	5	55	86	10	119

[a] Phoenix Airport 1965-70, Mesa Sewage Treatment Plant 1971-78.

[b] Site farmer.

[c] Estimated to be same as existing irrigation water.

[d] Based on two crops/year.

[e] January only.

[f] F = B + D

[g] G = C + E

[h] I = D × H

[i] J = E × H

Note: All numbers rounded off to nearest whole number.

TABLE G-5. TEST SITE NUTRIENT BALANCE AND VALUE, 1965-77

Year 19___	Crop	Fertilizer Used[a] (%)	Fertilizer Applied[a]		Recommended Fertilizer[b]		Fertilizer Cost[b]	
		N P K	(kg/ha/crop)[c]	(kg/ha/yr)[d]	(kg/ha/crop)[c] N P K	(kg/ha/yr)[d] N P K	($/ha/crop)[c]	($/ha/yr)[d]
I	II	III	IV	V	VI	VII	VIII	IX
65	Bermuda grass	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
66	"	"	"	"	"	"	"	"
67	"	"	"	"	"	"	"	"
68	"	"	"	"	"	"	"	"
69	"	"	"	"	"	"	"	"
70	"	"	"	"	"	"	"	"
71	"	"	"	"	"	"	"	"
72	"	"	"	"	"	"	"	"
73	Wheat, sorghum	"	"	"	"	"	"	"
74	Barley, corn, sorghum	"	"	"	"	"	"	"
75	Barley, corn, sorghum	"	"	"	"	"	"	"

(continued)

TABLE G-5(continued)

Year 19___	Crop	Fertilizer Useda (%) N P K	Fertilizer Applied[a] (kg/ha/crop)[c]	Fertilizer Applied[a] (kg/ha/yr)[d]	Recommended Fertilizer[b] (kg/ha/crop)[c] N P K	Recommended Fertilizer[b] (kg/ha/yr)[d] N P K	Fertilizer Cost[b] ($/ha/crop)[c]	Fertilizer Cost[b] ($/ha/yr)[d]
I	II	III	IV	V	VI	VII	VIII	IX
76	Barley, sorghum	"	"	"	"	"	"	"
77	Barley,corn	"	"	"	"	"	"	"
Total				0			0	
Avg.				0			0	

(continued)

TABLE G-5 (continued)

	Fertilizer Nutrients b						Nutrients in Effective Irrigation Water^e						Value of Nutrient in Irrigation^b					
	(kg/ha/crop)^c			(kg/ha/yr)^d			(kg/ha/crop)^c			(kg/ha/yr)^d			($/ha/crop)^c			($/ha/yr)^d		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
	X			XI			XII			XIII			XIV			XV		
65	N.A.			N.A.			1,073	429	858	1,073	429	858	708	283	566	708	283	566
66	"			"			1,238	495	980	1,238	495	980	817	327	647	817	327	647
67	"			"			1,423	569	1,138	1,423	569	1,138	939	376	751	939	376	751
68	"			"			1,633	653	1,306	1,633	653	1,306	1,078	431	862	1,078	431	862
69	"			"			1,760	704	1,408	1,760	704	1,408	1,162	465	929	1,162	465	929
70	"			"			1,705	682	1,364	1,705	682	1,364	1,125	450	900	1,125	450	900
71	"			"			1,415	566	1,132	1,415	566	1,132	934	374	747	934	374	747
72	"			"			1,233	493	986	1,233	493	986	814	325	651	814	325	651
73	"			"			389	156	311	777	311	622	257	103	206	513	205	411
							388	155	311				256	102	205			

(continued)

TABLE G-5 (continued)

	Fertilizer Nutrients[b]						Nutrients in Effective Irrigation Water[c]						Value of Nutrient in Irrigation[b]					
	[c] (kg/ha/crop)			[d] (kg/ha/yr)			[c] (kg/ha/crop)			[d] (kg/ha/yr)			[c] ($/ha/crop)			[d] ($/ha/yr)		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
	X			XI			XII			XIII			XIV			XV		
74	N.A.			N.A.			325	130	263				214	86	174			
							324	130	263				214	86	173			
							324	129	262	973	389	788	214	85	173	642	257	520
75	"			"			451	181	361				298	119	238			
							451	180	361				298	119	238			
							450	180	360	1,353	541	1,082	297	119	238	893	357	714
76	"			"			457	183	365									
							456	182	365	913	365	730				603	240	482
77	"			"			413	165	330				273	109	218			
							412	165	330	825	330	660	272	109	218	545	218	436
Total										16,321	6,527	13,054				10,773	4,308	8,616
Avg.										1,255	502	1,004				829	331	663

(continued)

TABLE G-5 (continued)

	Total Nutrient Supplied						Nutrient Uptake by Crop[f]						Nutrient Removal by Leachate		
	[c] (kg/ha/crop) XVI[g]			[d] (kg/ha/yr) XVII[h]			[c] (kg/ha/crop) XVIII			[d] (kg/ha/yr) XIX			[d] (kg/ha/yr) XX		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
65	Same as XII and XIII						300	80	80						
										300	80	80	1499	136	504
66							300	80	80						
										300	80	80	1814	164	610
67							300	80	80						
										300	80	80	2130	193	716
68							300	80	80						
										300	80	80	2501	226	841
69							300	80	80						
										300	80	80	2742	248	922
70							300	80	80						
										300	80	80	2645	239	889
71							300	80	80						
										300	80	80	2083	189	700
72							300	80	80						
										300	80	80	1772	160	596
73							100	60	80						
							170	70	60						
										270	130	140	909	82	306

(continued)

TABLE G-5 (continued)

	Total Nutrient Supplied						Nutrient Uptake by Crop[f]						Nutrient Removal by Leachate		
	(kg/ha/crop)[c]			(kg/ha/yr)[d]			(kg/ha/crop)[c]			(kg/ha/yr)[d]			(kg/ha/yr)[d]		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
	XVI[g]			XVII[h]			XVIII			XIX			XX		
74	Same as XII and XIII						80	20	60						
							120	40	125						
							120	50	95	320	110	280	1322	120	445
75							100	40	80						
							120	40	125						
							120	50	95	340	130	300	1981	179	666
76							100	40	80						
							150	50	95						
										250	90	175	1202	109	404
77							100	40	80						
							150	40	125						
										250	80	205	993	90	334
Total										3,830	1,180	1,740	23,593	2,135	7,933
Avg.										295	91	134	1,815	164	610

(continued)

TABLE G-5 (continued)

	Nitrogen Losses to Atmosphere[f] (kg/ha/yr) XXI	Nutrient Residual in Topsoil (kg/ha/yr) N	P	K
65	50	- 776	213	274
66	50	- 926	251	290
67	50	-1,057	296	342
68	50	-1,218	347	385
69	50	-1,332	376	406
70	50	-1,290	363	395
71	50	-1,018	297	352
72	50	- 889	253	310
73	50	- 452	99	176
74	50	- 719	159	63
75	50	-1,018	232	116
76	50	- 589	166	151
77	50	- 468	160	121

(continued)

TABLE G- 5 (continued)

	Nitrogen Losses to Atmosphere[f] (kg/ha/yr) XXI	Nutrient Residual in Topsoil (kg/ha/yr) N	P	K
Total	650	- 11,752	3,212	3,381
Avg.	50	-904	247	260

[a] Individual crop.
[b] Total crops.

[1] Site farmer.
[2] Arizona State University Agricultural Extension Service.
[3] Estimated to be same as existing irrigation water.
[4] Estimated.
[5] XVI = X + XII (columns).
[6] XVII = XI + XIII (columns).
[7] XXII = XVII-(XIX + XX + XXI) (columns).
[8] (-) negative quantity indicates leaching or other mineral removal mechanism from soil.

TABLE G-6. CONTROL SITE, NUTRIENT BALANCE AND VALUE, 1965-77

Year 19___	Crop	Fertilizer Used[a] (%)			Fertilizer Applied[a]		Recommended Fertilizer[b]						Fertilizer Cost[b]	
					(kg/ha/crop)[c]	(kg/ha/yr)[d]	(kg/ha/crop)[c]			(kg/ha/yr)[d]			($/ha/crop)[c]	($/ha/yr)[d]
		N	P	K			N	P	K	N	P	K		
I	II	III			IV	V	VI			VII			VIII	
65	Barley	82^c	0	0	112		155-190	45 60	0				22.40	
	Sorghum	82^c	0	0	112		140-190	0	0				22.40	
						224				295-380	45-60	0		45
66	Barley	82^c	0	0	112		155-190	45-60	0				22.40	
	Cotton	20^f	0	0	924		140-190	0	0				92.40	
						1,036				295-380	45-60	0		115
67	Cotton	20^f	0	0	924		140-190	0	0				92.40	
	Sorghum	82^c	0	0	112		140-190	0	0				22.40	
						1,036 1,036				280-380	0	0		115
68	Alfalfa	13^g	39	0	224		20-30	110	0				51.50	
						224				20-30	110	0		51

(continued)

TABLE G-6 (continued)

Year 19___ I	Crop II	Fertilizer Used[a] (%) III N	P	K	Fertilizer Applied[a] (kg/ha/crop)[c] IV	(kg/ha/yr)[d] V	Recommended Fertilizer[b] (kg/ha/crop)[a] VI N	P	K	(kg/ha/yr)[d] VII N	P	K	Fertilizer Cost[b] ($/ha/crop)[c] VIII	($/ha/yr)[d] IX
69	Alfalfa	13[h]	39	0	224		20–30	110	0				51	
						224				20–30	110	0		51
70	Wheat	48[h]	0	0	112		155–190	45–60	0				22	
	Sorghum	82[c]	0	0	112		140–190	0	0				22	
						224				295–380	45–60	0	22	44
71	Wheat	48[h]	0	0	112		155–190	45–60	0				22	
	Sugar beet seed	48[h]	0	0	224		175	220	110				49	71
						336				330–365	265–280	110		
72	Sugar beet seed	48[h]	0	0	224		175	220	110				49	
	Sorghum	82[c]	0	0	112		140–190	0	0				22	
						336				315–365	220	110		71

(continued)

TABLE G–6 (continued)

Year 19___	Crop	Fertilizer Used[a] (%)			Fertilizer Applied[a]		Recommended Fertilizer[b]						Fertilizer Cost[b]	
					c (kg/ha/crop)	d (kg/ha/yr)	c (kg/ha/crop)			d (kg/ha/yr)			c ($/ha/crop)	d ($/ha/yr)
		N	P	K			N	P	K	N	P	K		
I	II		III		IV	V		VI			VII		VIII	IX
73	Sudan grass	82	0	0	112		165–190	0	0				22	
						112				165–190	0	0		22
74	Alfalfa	13	39	0	224		20–30	110	0				51	
						224				20–30	0	0		51
75	Wheat	48	0	0	112		155–190	45–60	0					
	Sudan grass	82	0	0			165–190	0	0				22	
						224				320–380	45–60	0		
76	Sudan grass	82	0	0	112		165–190	0	0				22	
						112				165–190	0	0		22
77	Cotton	82	0	0	204		140–190	0	0				44	
						204				140–190	0	0		44

(continued)

TABLE G-6 (continued)

Year 19___	Crop	Fertilizer Used[a] (%)			Fertilizer Applied[a]		Recommended Fertilizer[b]						Fertilizer Cost[b]	
					[c] (kg/ha/crop)	[d] (kg/ha/yr)	[c] (kg/ha/crop)			[d] (kg/ha/yr)			[c] ($/ha/crop)	[d] ($/ha/yr)
		N	P	K			N	P	K	N	P	K		
I	II		III		IV	V		VI			VII		VIII	IX
Total						4,516				2,660- 3,290	885- 960		220	746
Avg.						347				205	68-74		17	57

(continued)

TABLE G-6 (continued)

Year 19__	Fertilizer Nutrients[b]						Nutrients in Effective Irrigation Water[f]						Value of Nutrient in Irrigation[b]					
	(kg/ha/crop)[c]			(kg/ha/yr)[d]			(kg/ha/crop)[c]			(kg/ha/yr)[d]			($/ha/crop)[c]			($/ha/yr)[d]		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
	X			XI.			XII			XIII			XIV			XV		
65	92	0	0				37	5	52				25	3	35			
	92	0	0				37	4	52				24	3	34			
				184	0	0				74	9	104				49	6	69
66	92	0	0				37	5	52				25	3	35			
	185	0	0				37	4	52				24	3	34			
				277	0	0				74	9	104				49	6	69
67	185	0	0				30	4	42				20	3	28			
	92	0	0				30	3	41				19	2	27			
				277	0	0				60	7	83				39	5	55
68	29	87	0				74	9	104				49	6	69			
				29	87	0				74	9	104				49	6	69
69	29	87	0				74	9	104				49	6	69			
				29	87	0				74	9	104				49	6	69
70	54	0	0				41	5	58				27	4	38			
	92	0	0				41	5	58				27	3	38			
				146	0	0				82	10	116				54	7	76
71	54	0	0				37	5	52				25	3	35			
	108	0	0				37	4	52				24	3	34			
				162	0	0				74	9	104				49	6	69

(continued)

TABLE G-6 (continued)

Year 19___	Fertilizer Nutrients[b]						Nutrients in Effective Irrigation Water[1]						Value of Nutrient in Irrigation[b]					
	(kg/ha/crop)[c]			(kg/ha/yr)[d]			(kg/ha/crop)[c]			(kg/ha/yr)[d]			($/ha/crop)[c]			($/ha/yr)[d]		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
	X			XI			XII			XIII			XIV			XV		
72	108	0	0				68	8	94				45	6	62			
	92	0	0				68	8	94				45	5	62			
				200	0	0				136	16	188				90	11	124
73	92	0	0				82	10	116				54	7	76			
				92	0	0				82	10	116				54	7	76
74	29	87	0				74	9	104				49	6	69			
				29	87	0				74	9	104				49	6	69
75	54	0	0				37	5	52				49	6	69			
	92	0	0				37	4	52									
				146	0	0				74	9	104				49	6	69
76	92	0	0				124	15	173				82	10	115			
				92	0	0				124	15	173				82	10	115
77	167	0	0				120	15	168				79	10	111			
				167	0	0				120	15	168				79	10	111
Total				1,830	261	0				1,122	136	1,572				741	92	1,040
Avg.				141	20	0				86	10	121				57	7	80

(continued)

TABLE G-6 (continued)

Year	Total Nutrient Supplied						Nutrient Uptake by Crop[1]						Nutrient Removal by Leachate		
	c (kg/ha/crop) XVI			d (kg/ha/yr) XVII			c (kg/ha/crop) XVIII			d (kg/ha/yr) XIX			d (kg/ha/yr) XX		
19__	N	P[k]	K	N	P[l]	K	N	P	K	N	P	K	N	P	K
65	136	5	52				60	10	40						
	136	4	52				110	15	30						
				258	9	104				170	25	70	101	21	85
66	129	5	52				55	10	38						
	222	4	52				190	30	60						
				351	9	104				245	40	98	105	22	88
	215	4	42				180	30	45						
	122	3	41				100	15	21						
				337	7	83				280	45	66	93	20	78
68	103	96	104				80	50	20						
				103	96	104				80	50	20	85	18	72
69	103	96	104				80	80	24						
				103	96	104				80	80	24	87	18	74
70	95	5	58				60	10	40						
	133	5	58				110	15	30						
				228	10	116				170	25	70	118	25	99
71	91	5	52				35	10	35						
	145	4	52				100	15	30						
				236	9	104				135	15	65	80	17	67

(continued)

TABLE G-6 (continued)

Year	Total Nutrient Supplied						Nutrient Uptake by Crop						Nutrient Removal by Leachate		
	[c] (kg/ha/crop)			[d] (kg/ha/yr)			[c] (kg/ha/crop)			[d] (kg/ha/yr)			[d] (kg/ha/yr)		
19__	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
	XVI[k]			XVII[l]			XVIII			XIX			XX		
72	176	8	94				100	25	35						
	160	8	94				110	25	35						
				336	16	188				210	50	70	317	67	267
73	174	10	116				70	30	45						
				174	10	116				70	30	45	112	24	94
74	103	96	104				45	80	25						
				103	96	104				45	80	25	105	22	88
75	91	5	52				35	10	35						
	129	4	52				70	15	45						
				220	9	104				105	25	80	85	18	72
76	216	15	172				70	30	45						
				216	15	173				70	30	45	287	60	242
77	287	15	168				185	50	33						
				287	15	168				185	50	33	91	19	77
Total				2,952	397	1,572				1,845	545	711	1,666	351	1,403
Avg.				227	31	121				142	42	55	128	27	108

(continued)

TABLE G-6 (continued)

Year 19__	Nitrogen Losses to Atmosphere ^{l} (kg/ha/yr) XXI	Nutrient Residual in Topsoil (kg/ha/yr) N	P_m XXII	K
65	10	-23	-37	-51
66	10	-9	-53	-82
67	10	-46	-58	-61
68	10	-72	28	12
69	10	-74	-2	6
70	10	-70	-40	-53
71	10	11	-23	-28
72	10	-201	-101	-149
73	10	-18	-44	-23
74	10	-57	-6	-9
75	10	20	-34	-48
76	10	-151	-75	-114
77	10	1	-54	58
Total	130	-689	-499	-542
Avg.	10	-53	-38	-42

(continued)

TABLE G-6 (continued)

---

[a] Site farmer.
[b] Arizona State University Agricultural Extension Service.
[c] Individual crop.
[d] Total crops.
[e] As NH_3.
[f] As ammonium sulfate.
[g] As ammophos.
[h] Urea.
[i] Estimated to be same as existing irrigation water.
[j] Estimated.
[k] XVI = X + XII (columns).
[l] XVII = XI + XIII (columns).
[m] XXII = XVII - (XIX + XX + XXI) (columns).

TABLE G-7 . TEST SITE CROP YIELD AND NUTRIENT UPTAKE, 1965-77

Year[b] 19___	Crop[b]	Yield Green Weight[c] (1,000 kg/ ha/yr)	Yield Dry Weight[c] (1,000 kg/ha/yr)	Nutrient Supplied (kg/ha/yr)			Nutrient Uptake[c] (kg/ha/yr)			Uptake Efficiency (%)			Combined Nutrient Uptake Efficiency
				N	P	K	N	P	K	N	P	K	(%)
65	Bermuda Grass[a]	40	4	1073	429	858	300	80	80	28	19	9	19
66	1	40	4	1238	495	980	300	80	80	24	16	8	16
67	1	40	4	1423	569	1138	300	80	80	21	14	7	14
68	1	40	4	1633	653	1306	300	80	80	18	12	6	12
69	1	40	4	1760	704	1408	300	80	80	17	11	6	11
70	1	40	4	1705	682	1364	300	80	80	18	12	6	12
71	1	40	4	1415	566	1132	300	80	80	21	14	7	14
72	1	40	4	1233	493	986	300	80	80	24	16	8	16
73	Wheat	0.4	2				100	60	80				
	Sorghum	11	4	777	311	622	170	70	60	32	42	32	35
74	Barley	0.7	0.2				80	20	60				
	Corn	17	5				120	40	125				
	Sorghum	11	4	973	389	788	120	50	95	33	28	36	32
75	Barley	0.7	0.2				100	40	80				
	Corn	17	5				120	40	125				
	Sorghum	11	4	1353	541	1082	120	50	95	25	24	28	26

(continued)

TABLE G-7. (continued)

Year[b] 19__	Crop[b]	Yield Green Weight[c] (1,000 kg/ha/yr)	Yield Dry Weight[c] (1,000 kg/ha/yr)	Nutrient Supplied (kg/ha/yr)			Nutrient Uptake (kg/ha/yr)			Uptake Efficiency (%)			Combined Nutrient Uptake Efficiency (%)
				N	P	K	N	P	K	N	P	K	
76	Barley	0.7	0.2				100	40	80				
	Sorghum	11	4	913	365	730	150	50	95	27	25	24	25
77	Barley	0.7	0.2				100	40	80				
	Corn	17	5	825	330	660	150	40	125	30	24	31	28
Total				16,321	6,527	13,054	3,830	1,188	1,740				
Avg.				1,255	502	1,004	295	91	134	24	20	16	20

[a] Bermuda Grass=1.

[b] Site farmer.

[c] Estimated.

TABLE G-8. CONTROL SITE CROP YIELD AND NUTRIENT UPTAKE, 1965-77

Year[a] 19___	Crop[a]	Yield Green Weight[b] (1,000 kg/ha/yr)	Yield Dry Weight[b] (1,000 kg/ha/yr)	Nutrient Supplied (kg/ha/yr)			Nutrient Uptake (kg/ha/yr)			Uptake Efficiency (%)			Combined Nutrient Uptake Efficiency (%)
				N	P	K	N	P	K	N	P	K	
65	Barley	3	2.2				60	10	40				
	Sorghum	11	3.9	258	9	104	110	15	30	66	100	67	78
66	Barley	3.0	2.2				55	10	38				
	Cotton	11	3.9	351	9	104	190	30	60	70	100	94	88
67	Cotton	11	3.9				180	30	45				
	Sorghum	3	2.2	337	7	83	100	15	21	83	100	80	88
68	Alfalfa	7	0.7	103	96	104	80	50	20	78	52	19	50
69	Alfalfa	7	0.7	103	96	104	80	80	24	78	83	23	61
70	Wheat	4	2.2				40	10	30				
	Sorghum	11	3.9	228	10	116	110	15	35	66	100	86	74
71	Wheat	4	2.2				35	10	35				
	Sugar beet seed	3	2.0	236	9	104	100	15	30	57	100	62	73
72	Sugar beet seed	3	2.0				100	25	35				
	Sorghum	11	3.9	336	16	188	110	25	35	63	100	37	67
73	Sudan grass	17	3.5	174	10	116	70	30	45	40	100	39	60
74	Alfalfa	7	0.7	103	96	104	45	80	25	43	83	24	50

(continued)

APPENDIX H
CONTRACTS WITH FARMERS

MESA TEST SITE LEASE

CITY OF MESA
ARIZONA
MUNICIPALLY OWNED UTILITIES • ELECTRICITY • NATURAL GAS • WATER
55 NORTH CENTER STREET • P. O. BOX 1466 • 85201 • 834-2011

June 23, 1975

Mr. Gary Feezor
325 South Olive
Mesa, Arizona 85202

Dear Mr. Feezor:

Subject: Agricultural Lease at the Mesa Sewage Treatment Plant

This letter will serve as a supplemental agreement to subject agreement. Its purpose is to add to the area covered by that lease agreement the following described parcel:

> The South Half of the Northeast Quarter of Section 18, Township One North, Range Five East of the Gila and Salt River Base and Meridian, Maricopa County, Arizona,
>
> EXCEPT that portion of the above described premises described as follows:
>
> That part of the Southeast Quarter of the Northeast Quarter of said Section 18 and that part of the Northeast Quarter of the Southeast Quarter of said Section 18, described as follows, the course given being based on an assumed course of East for the South line of the Southeast Quarter of said Section 18, to wit: BEGINNING at the East quarter section corner of said Section 18; thence South 0° 54' West along the Section line 8.00 feet to the center line of an existing road; thence South 89° 59' West along the center line of said road 1036.32 feet; thence North 0° 23' East along the center line of an existing road 1320.00 feet; more or less, to a point on the North line of the Southeast Quarter of the Northeast

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> Quarter of said Section 18; thence in an Easterly direction along the North line of the Southeast Quarter of the Northeast Quarter of said Section 18, 1020.00 feet, more or less, to the Northeast corner of the Southeast Quarter of the Northeast Quarter of said Section 18; thence in a Southerly direction along the section line, 1320.00 feet more or less, to the Point of Beginning.

The area of this parcel is 47 acres, making the new total area covered by the lease 142 acres. All terms of the lease agreement shall apply to this added area, except that to the rental rate of $50 per acre, shall be added 4%, or $2.00 per acre for applicable sales tax; therefore the total rental rate for this 47 acres shall be $52.00 per acre.

This addition to the lease area shall be effective July 1, 1975. If this is acceptable, please sign and return one copy for our files.

Yours truly,

Dean Sloan
DEAN SLOAN
City Engineer

DES:jlk

APPROVED BY:
C. K.
C. K. Luster

ACCEPTED BY:
Gary Feezor
Gary Feezor

WASTEWATER TREATMENT PLANT FARM
LEASE AGREEMENT

THIS LEASE AGREEMENT, made and entered into this 22nd day of December, 1972, by and between the City of Mesa, a municipal corporation, hereinafter referred to as the City, and Gary Feezor hereinafter referred to as the Lessee;

WITNESSETH:

THAT WHEREAS, the City operates a wastewater treatment plant which produces effluent that is suitable for irrigation of crops; and

WHEREAS, the City owns land suitable for irrigated crops and until such land is needed for other purposes, the City desires to lease same to the Lessee for agricultural purposes only, on condition that Lessee uses effluent from the wastewater treatment plant to irrigate such land in a manner that will conform to the regulations of the State of Arizona and County of Maricopa; and

WHEREAS, said premises were publicly offered for lease, and the Lessee was the highest and best bidder therefor on the terms and conditions hereinafter set forth;

NOW THEREFORE, for and in consideration of the foregoing premises it is agreed as follows:

1. DESCRIPTION AND AREA: That the City hereby leases to the Lessee the following described premises:

> Parcel No. 1 (approximately 86 acres): The Northwest Quarter of Section 18, Township 1 North, Range 5 East of the Gila and Salt River Base and Meridian, Maricopa County, Arizona;
> EXCEPT, the South Half of the North Half and the North Half of the South Half of Lot 2 (which said Lot 2 is sometimes referred to as the Southwest Quarter of said Northwest Quarter) deeded to the United States of America in instruments recorded March 23, 1954, in Docket 1311, at Page 210, and
> EXCEPT, that portion lying within the channel of the Salt River which is approximately 54 acres.
>
> Parcel No. 2 - (approximately 9 acres): Lying directly West of the treatment plant.

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The total area to be leased is approximately 95 acres. This area will be used for the purpose of computing the rental payment.

2. TERM: The term of this lease agreement shall be three (3) years, commencing January 1, 1973 and ending December 31, 1975.

3. OPTION TO EXTEND: The parties hereto shall, with the approval of both parties, have the right to extend the term of this lease for a further three (3) years, commencing on January 1, 1976 and ending December 31, 1978. Each party shall have the right to require the other to indicate its approval or disapproval of exercising this option no later than October 31, 1975.

4. RENTAL RATE: The annual rental for the ninety-five (95) acres included in this lease shall be the sum of Fifty and 00/100 ($50.00) Dollars per acre. Said rental shall be payable in two semi-annual payments; the first payment shall be paid on or before January 1st and the second payment shall be on or before July 1st of each year, except that the first payment, that for the six-month period commencing January 1, 1973, shall be included with the sealed bid submitted for this lease.

Such rental payments shall be subject to the credits to be received for leveling as hereinafter set forth.

5. LAND LEVELING: The Lessee agrees to improve the grade of certain portions of the premises by land leveling methods to permit proper border irrigation. The costs of said leveling shall be credited to the next semi-annual rental payment following the leveling work. The amount of such costs shall be based upon actual invoiced expenditures and/or hourly equipment rental rates to be mutually agreed upon by both parties hereto.

6. AGRICULTURAL USE LIMITATIONS: The Lessee shall be limited to using these premises for certain approved agricultural purposes. The use shall be generally for irrigation and growing of crops and may include grazing by cattle and horses. Livestock feedlot operations will not be permitted.

7. EFFLUENT USE: The Lessee agrees to utilize effluent from the City's nearby wastewater treatment plant as the primary source of water for irrigating the premises and agrees to use as much of the effluent as possible the year around without causing continuous ponding in any one location.

8. PRESENT IMPROVEMENTS: Certain of the improvements existing (prior to December 31, 1972) are temporary and are the property of the present leaseholder. Under the terms of the Lease which terminates December 31, 1972, the leaseholder shall be allowed to sell or remove such improvements. Included is the turbine pump with gearhead, fences, and corrals. Also, the current (prior to December 31, 1972) leaseholder owns an unused interest in the gas engine by virtue of having paid one-half the cost of a major overhaul in March, 1972. This interest is computed to be $1,000.00 and this amount shall be paid by any new Lessee to the present leaseholder. The present leaseholder has an interest in a new planted grain crop which any new Lessee shall purchase at the rate of $35.00 per acre.

9. ENGINE PUMP DRIVE: The existing engine driving the irrigation pump is the property of the City. The City agrees to maintain said engine and make future overhauls as necessary and to furnish the digester gas to power the engine at no cost to the Lessee.

10. PUMP AND GEARHEAD: The turbine pump and gearhead shall be furnished, operated, and maintained by the Lessee.

11. FUTURE IMPROVEMENTS: The Lessee shall be allowed to make such other agricultural type improvements as he may desire in addition to the leveling, including fencing, which shall not be considered permanent by the terms of this lease agreement. Upon the termination of this lease agreement, except in case of default on the part of the Lessee, the Lessee shall be allowed to sell or remove such other improvements.

12. HEALTH REGULATIONS: The Lessee agrees to conduct his operations in accordance with current applicable regulations of both Maricopa County Health

Department and the Arizona State Department of Health. The Lessee shall control the ponding of water on the premises in such a manner as to prevent the growth of mosquitoes. In the event that mosquitoes are produced on the premises the Lessee shall be required to eliminate them immediately.

13. RIGHT TO RECLAIM: The City has the right to reclaim all or any portion of the above described property at any time for any use whatsoever other than agricultural use, and upon reclaiming thereof, any interest of the Lessee with respect to said land or any portion thereof, shall immediately terminate. The City may reclaim all, or any portion, of said land upon giving sixty (60) days previous written notice, to Lessee of the need therefor, and if at the end of sixty (60) days an existing grain crop is not mature, additional time will be allowed to permit maturing and harvesting of said crop, and in the event any portion of the land is taken on which rent for the year in which it is taken has been paid, the City agrees to make an appropriate adjustment for such rental.

14. HOLD HARMLESS: The Lessee agrees to protect and hold harmless the City of and from all claims of every nature in connection with the use made of said premises by the Lessee, including but not limited to all claims for damage by persons residing within the area for damage to their property by reason of odors, and the use of said land by Lessee.

15. WELL WATER: Well water is available in very limited quantities for watering livestock; it is not safe for human consumption. The City will deliver this water to an existing meter near the premises; the Lessee shall pay for it at the current applicable rate for such service.

16. DEFAULT: In the event that Lessee is in default of any obligations or conditions hereunder agreed to be performed by him, or any rental shall be due and unpaid, and in the event such default is not cured or corrected by Lessee within ten (10) days after written notice of said default from City to Lessee, this lease at the option of City, may be cancelled and all rights and privileges and obligations of Lessee hereunder shall be terminated or the City may take such other and further steps as it may deem proper in the premises.

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17. ASSIGNMENT OF LEASE: The Lessee agrees not to assign this lease and agreement or sublet any portion of the premises without first securing the written consent of the City.

IN WITNESS WHEREOF, the parties have executed these presents by their duly authorized officers or individuals.

CITY OF MESA

By J. L. Petrie

Gary Feezor "Lessee"

CITY OF MESA
Property Division
P. O. Box 1466
Mesa, Arizona 85201

MESA CONTROL SITE LEASE

LEASE AGREEMENT

This Lease Agreement made and entered into between CITY OF MESA, a municipal corporation, hereinafter referred to as Lessor, and JOHN T. BUNN III., and ARTHUR A. CARROLL, a partnership, hereinafter referred to as Lessee,

WITNESSETH:

That for and in consideration of the terms, covenants and conditions of this Lease Agreement to be kept and performed by the respective parties hereto, it is hereby agreed by and between the parties hereto as follows:

1. The Lessor does by these presents lease unto the Lessee that certain property situated in Maricopa County, Arizona, containing approximately 48 tillable acres more or less, and more particularly described as a portion of the following, to-wit:

> The Northeast Quarter of the Northeast Quarter of said Section 18, Township One North, Range Five East of the Gila and Salt River Base and Meridian, Maricopa County, Arizona;
>
> EXCEPT the West 300.00 feet thereof;
>
> That part of the Southeast Quarter of the Northeast Quarter of said Section 18 and that part of the Northeast Quarter of the Southeast Quarter of said Section 18 described as follows, the courses given being based on an assumed course of East for the South line of the Southeast Quarter of said Section 18, to-wit:
>
> BEGINNING at the East Quarter Section corner of said Section 18, thence South 0° 54' West along the section line 8.00 feet to the center line of an existing road; thence South 89° 59' West along the center line of said road 1036.32 feet: thence North 0° 23' East along the center line of an existing road 1320.00 feet, more or less, to a point on the North line of the Southeast Quarter of the Northeast Quarter of said Section 18; thence in an Easterly direction along the North line of the Southeast Quarter of the Northeast Quarter of said Section 18, 1020.00 feet, more or less, to the Northeast corner of the Southeast Quarter of the Northeast Quarter of said Section 18; thence in a Southerly direction along the Section line 1320.00 feet, more or less, to the Point of Beginning.

for a term of one (1) year, commencing January 1, 1977, and ending at midnight, December 31, 1977.

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2. The Lessee hereby accepts the lease of said property for said term and agrees to pay Lessor as rent $165.00 per acre for 48 acres for a total amount of $7,920.00, Lessor to pay applicable rental taxes on or before January 1, 1977. Rental to be paid as follows:

January 1, 1977 - $3,960.00
July 1, 1977 - $3,960.00

3. The Lessee agrees to pay to the Salt River Valley Water Users' Association promptly when due, the assessments levied against the leased premises for the year 1977 and pay to the Salt River Valley Water Users' Association promptly when due all charges for water in excess of the amount of water received upon the payment of the assessment due upon the leased premises.

4. The Lessor agrees to pay to the proper authorities before delinquency all taxes and assessments levied and assessed against the leased premises and the improvements thereon throughout the term of this Lease Agreement.

5. Lessee agrees throughout the term of this Lease that he will not assign, underlet, or part with possession of the whole or any part of the leased premises, or assign this Lease or any right herein without the consent in writing of the Lessor. Any such underletting, subletting, or assignment without the written consent of the Lessor shall be null and void, and shall create no interest hereunder or in or to said leased premises or any part thereof.

6. Lessee agrees that throughout the term of this Lease he will cultivate and farm the leased premises in good and farmerlike manner, and during said term, he will keep said premises reasonably free and clear of all noxious weeds and grasses.

7. The Lessee agrees to keep and maintain the leased premises and the whole thereof and all and singular of the improvements thereon and appurtenants thereto, in as good condition and state of repair as the same shall be at the date of the commencement of this Lease, reasonable wear and tear alone excepted. Without limitation to the foregoing, the Lessee agrees that he will use reasonable care to maintain the concrete irrigation ditches now situated upon the

leased premises and not allow the dirt supporting the sides of said concrete ditches to be removed by cultivation or be washed away therefrom so as to allow said ditches to be cracked or broken.

8. The Lessor reserves unto itself the right to enter upon the leased premises for the purposes of inspecting the same or for any other lawful purposes not in conflict with the Lessee's right to farm the leased premises. It is specifically understood that the Lessee shall have no right whatsoever to remove any sand, rock, or dirt from the leased premises.

9. The Lessee agrees to indemnify and save the Lessor harmless from any and all liability, loss, cost and expense by reason of the personal injuries or death of any person or persons in or upon the leased premises and by reason of damage to personal property in or upon the leased premises as the result of the use of said leased premises, or any part thereof, by the Lessee.

10. The Lessee agrees that he will not make any material alterations to the leased premises or property unless and until the same are approved in writing by the Lessor. Any alterations and improvements which Lessee may make shall be at the expense of the Lessee, and the Lessee agrees to keep the leased premises free and clear from any liens which may arise from work performed, materials furnished, or obligations incurred by the Lessee during the term of this lease.

11. Lessee agrees that upon the termination of this Lease, it will surrender possession of the leased premises and property to Lessor in as good a condition as they are at the commencement of this Lease, reasonable wear and use excepted.

12. Lessee agrees that if default be made in the payment of any rent or other amounts required to be paid hereunder at the time when the same is above promised to be paid, or in the event of the violation by Lessee of any of the covenants or agreements herein contained to be kept and performed by Lessee,

the Lessor may thereupon, at their election, sue for the rent or any other amounts due hereunder, or sue for damages for such violation, or declare this Lease at an end and recover possession of the leased premises as if the same were held by forcible detainer, retaining all money theretofore received as rental and deposit on rental and being entitled to collect any unpaid rental or other amounts then due, or pursue any other legal remedy for the enforcement of Lessor's rights; the said Lessee hereby waives any notice of such election and any demand for the possession of said premises. No waiver of any breach, covenant, condition or stipulation herein contained shall be taken to be a waiver of any succeeding breach of the same covenant, condition or stipulation. The Lessee further agrees that in the event an attorney is employed by the Lessor and suit is brought to enforce the provisions hereof, the Lessee will pay to the Lessors a reasonable attorneys' fee to be fixed by the Judge of the Court.

13. This Lease, subject to the terms and conditions hereof, shall extend to and be binding upon the heirs, executors, administrators, successors and assigns of the respective parties hereto.

IN WITNESS WHEREOF, the parties hereto have executed this Lease this 23rd day of December, 1976.

Lessee: John T. Bunn III
John T. Bunn III
Arthur A. Carroll

Lessor:
CITY OF MESA

Acting City Manager

City Clerk

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STATE OF ARIZONA)
)ss
County of Maricopa)

On this the 23rd day of December, 1976, before me the undersigned Notary Public, personally appeared ~~J. A. PETRIE,~~ C.K. Luster Asst City Manager and DORTHE DANA, City Clerk, known to me to be the persons whose names are subscirbed to the within instrument and acknowledged that they executed the same for the purposes therein contained.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

Notary Public

My Commission expires:

June 7, 1979

STATE OF ARIZONA)
)ss
County of Maricopa)

On this the 23rd day of DECEMBER, 1976, before me, the undersigned Notary Public, personally appeared JOHN F. BUNN III & ARTHUR A. CARROLL known to me to be the persons whose name is subscribed to the within instrument and acknowledged that they executed the same for the purposes therein contained.

IN WITNESS WHEREOF, I hereunto set my hand and official seal.

Notary Public

My Commission expires:

My Commission Expires April 3, 1979

GLOSSARY

boreholes: Subsurface exploration holes drilled or excavated to obtain earth samples. Boreholes may be drilled to any depth for soil, and leachate samples, test well installation, and groundwater aquifer detection.

groundwater: The upper aquifer that receives the percolated irrigation water.

lysimeter: A porous ceramic-tipped cup device used to extract, when a vacuum is applied, a sample of percolating water from subsoil.

spatula: A sterilized hand tool in a protective wrapper used to collect uncontaminated soil samples.

tail water: The surface runoff water from an irrigated field.

test well: A special well constructed into the upper aquifer groundwater for sampling the groundwater.

well baler or well pump: Devices that may be used for pumping and obtaining groundwater samples from test wells. Varies in size depending on the well diameter. Well balers may consist of a weight, a test tube, a stopper, and a cord for collecting samples in a well. Well pumps are mechanical devices used to extract water from a well.

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